

DISCOVERY

Monthly Notebook

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Ph.D.

Outcrop Coal

W. D. EVANS,
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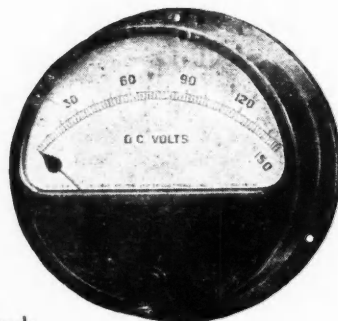
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DISCOVERY

THE MAGAZINE OF SCIENTIFIC PROGRESS

February, 1947 Vol. VIII. No. 2

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The Progress of Science

Colour Defectives and Industry

EIGHT per cent of the male population of Britain suffer from some degree of 'colour blindness'—or rather, defective colour vision, since blindness is misleading as a description of their condition. In 2% the defect is serious, while in the remaining 6% it is of varying severity. In women defective colour vision is much less common owing to the way in which it is inherited. The daughters of a colour defective man will not themselves be defective, but half of their sons will be, while half of their daughters will also be 'carriers'. Half the daughters of a carrier mother and a defective father, and all the daughters when both parents are defective, will themselves be defective.

The 2% of men who are seriously defective are classed as 'dichromats', because while the normal individual requires at least three coloured lights to match by mixture any given colour, the dichromat requires only two 'primaries'. There are two common types of dichromat; to one type red surfaces appear much darker than to a normal observer, while to the other type colours appear of normal brightness. Both, however, confuse reds with yellows and greens, and both can match any colour by a mixture of yellow and blue. The other 6% are known as 'anomalous trichromats'. Two types of 'trichromats' can be distinguished; the first type needs more red than a normal observer in matching yellow by a mixture of green and red lights; the second needs more green than a normal observer in making the same match. Both have difficulty in discriminating between slightly different hues in the red, orange, yellow and green regions.

Surprisingly few defectives are aware of their condition unless they have undergone a special test, partly owing to the way in which colours are learnt in infancy, and partly because the colour defective has a number of other clues from which he may often make a reasonably good guess at a colour. However, there is no doubt that in many industries the colour defective is at a disadvantage compared with the normal person. This has long been recognised by such employers as the railways and the Merchant Navy, where mistakes in colour recognition may endanger life, and for many years they have tested the colour vision of new entrants. In other industries which are affected,

such as colour printing, dyeing, branches of the electrical industry which make frequent use of colour codes on wires and components, and routine chemical analysis, there has been little systematic testing. As a result colour defectives may work for long periods before their defect is recognised, and their defect imposes a great strain upon them. Yet in most industries it would be possible for a colour defective to be transferred to a job in the same factory in which the defect would be no handicap. To quote an actual example, from horticulture; a man who was quite satisfactory while working in a cucumber house, was thought to be very careless when he was put on to picking tomatoes. The actual fact was that his colour defect made it impossible to tell when they were ripe. It is now generally recognised that it is unfair to both employee and employer that a man should have to learn of his unsuitability by bitter experience when a simple test would have revealed it at the outset.

A committee of the Colour Group of the Physical Society has recently carried out an investigation of this subject* from which it is clear that colour vision tests should be part of the regular medical examination of all school children before the age of twelve, so that colour defectives will be able to avoid careers in which they would be handicapped. Until this is done all the industries concerned should carry out a screening test on new entrants. Standardisation of the tests is also very necessary. Some seventy different tests are listed in the Report, many of which are of little value, and the discrepancies between those in regular use have already been the cause of unnecessary disappointments. For example, people classified as 'safe' by the R.A.F. have afterwards been rejected by the railways, although one would have expected that the requirements of the two services would be similar.

At the annual exhibition of the Physical Society, to be held in London on April 9-12, the Colour Group is arranging an exhibit that will illustrate this report.

Man-made Snow

AN American scientist, who has been working for several years on problems of icing that are important to aviation

* Report on Defective Colour Vision in Industry, p. 52. Physical Society. 3s. 6d.

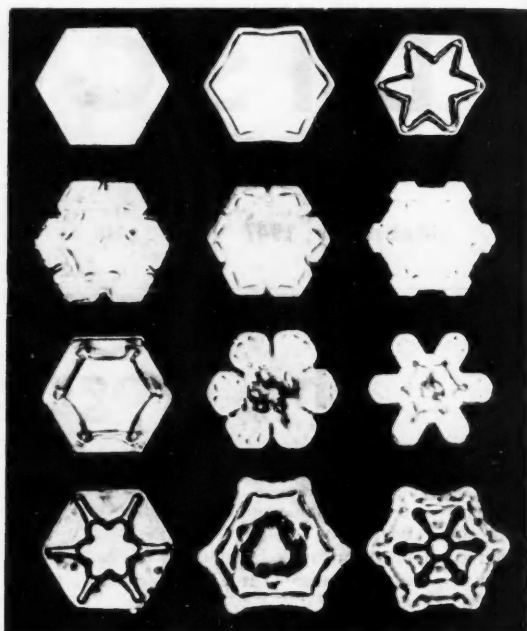
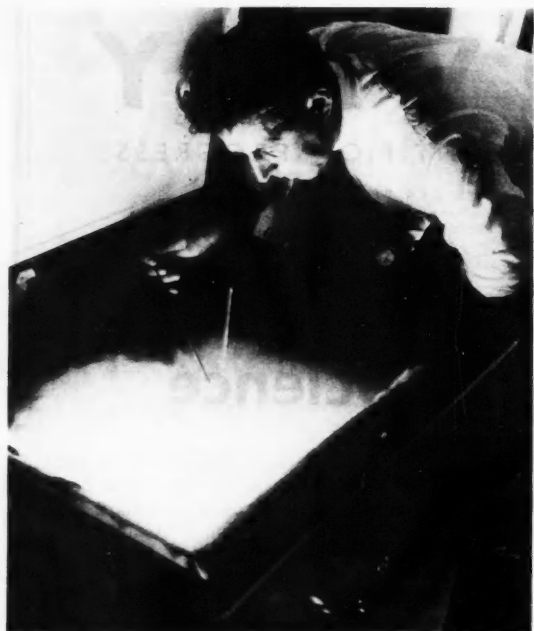


FIG. 1 (left).—Producing snow in an ordinary commercial freezing unit. A metal rod cooled by liquid air causes the change of the supercooled cloud of water vapour into snow crystals to start. FIG. 2.—Photomicrographs of replicas of some of these man-made snowflakes.

and on the effects of snow storms on the behaviour of radio sets in aircraft, has succeeded in producing snow in the laboratory. The scientist is Vincent J. Schaefer of the General Electric Research Laboratory, and he has just published his results in *Science* (1946, Vol. 104, p. 457). The apparatus he used was very simple, consisting of nothing more than an ordinary commercial freezing unit (seen in Fig. 1). When this is operated so that the temperature towards the top of the chamber is of the order of -10°C (the temperature at the bottom of the well is then around -20°C) a supercooled cloud is formed when one breathes into the apparatus. The water vapour in the breath undergoes rapid chilling but is converted into a cloud of water droplets and not into ice, though the temperature is well below that at which water normally changes into ice; this supercooled cloud will persist for five to ten minutes, depending on the rate at which the water droplets evaporate or diffuse on to the ice-coated walls of the well. When fine dusts were introduced into the chamber the supercooled cloud was still stable, and there was no sign of ice precipitating. When, however, a tiny pellet of dry ice (solid carbon dioxide, at a temperature of -70°F) was introduced the supercooled cloud was completely converted into very small snowflakes, resembling in shape and size the very fine snow known as 'diamond dust'. The same effect was obtained if instead of dry ice a metal rod that had been dipped in liquid air was passed through the cloud.

Fig. 2 shows the shapes of some of these man-made snowflakes. The photographs do not show actual snowflakes but replicas made from them by means of an

ingenious technique which Mr. Schaefer developed several years ago. The replicas are obtained by covering individual snowflakes with a cold dilute solution of a resin—Mr. Schaefer uses 1–2% polyvinyl formal dissolved in ethylene dichloride. The solvent evaporates very rapidly, leaving a very thin continuous film which preserves the shape of the snowflake; the latter is then melted, leaving the replica which can be photographed and studied at leisure. (More details of the procedure are given in *Nature*, 1942, Vol. 149, p. 81.) It is interesting to note that the British Glaciological Society's Snow Survey is intending to use the method for studying the changes in snowflake shapes that occur during a snowstorm.

Mr. Schaefer has tried out his method of producing an artificial deposit of snow on the large scale. He found that if dry ice in large quantities is sprinkled over snow clouds (these, of course, correspond in nature to the supercooled cloud formed in the laboratory experiments) a fall of snow occurs almost immediately. Such premature precipitation of snow clouds has possibilities; it might be used to keep snow from away, say, orchards and it has been somewhat fancifully suggested that winter sports resorts might be artificially created in places where there is usually only a very thin fall of snow!

At the recent meeting of the American Association for the Advancement of Science, Mr. Schaefer told of another of his successes. He had walked into a cold ground fog swinging a wire basket containing dry ice round his head. The fog parted ('falling' rather than 'lifting'), leaving a clear, fog-free lane.

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Hens' Eggs and Virus Vaccines

CULTIVATION of a specific virus that causes an animal disease is a tricky business. It involves the use of living culture medium, and it is essential that the medium be free from other viruses, and also from bacteria. In this respect the chick embryo is an almost ideal medium; it appears to harbour no naturally occurring viruses (whereas six are normally found in the laboratory mouse), and the chick embryo seems to develop no unsuspected immunities—it is apparently incapable of generating antibodies, although it is thought possible that occasional latent immunity to some virus diseases of poultry may be encountered due to the presence in the yolk of maternal antibody.

For these and other reasons hens' eggs have come to find important uses in virus-disease research. They can be utilised for the large-scale production of virus vaccines. They also provide an aid to diagnosis, for the appearance of chick-embryo tissue infected with virus varies considerably from virus to virus (Fig. 5) and it is often possible for an experienced research worker to identify the virus from inspection of the tissue.

There are several routes by which the embryo may be inoculated with virus. The chief ones are shown in Fig. 6. The choice of route depends largely upon the virus and upon the effect it is desired to study. For instance, to bring about an infection of the embryo's respiratory tract, inoculation is made into the amniotic cavity whose fluid has direct access to the requisite organs.

Many organisms other than viruses and rickettsiae* have been successfully cultivated in the chick embryo, including bacteria and protozoa causing diseases in man and in domestic animals. The grafting of foreign tissues to the membrane in the chick embryo known as the chorioallantois has often been accomplished and this has afforded a means of cultivating animal viruses which could not be induced to multiply in the ordinary embryo. For example, the virus causing abortion in mares was successfully propagated by grafting a piece of human amnion to the chorioallantois and then inoculating it with an emulsion of liver from aborted foals.

Chick-embryo methods have proved of great practical importance for the production of yellow fever, typhus (but *not* scrub typhus) and influenza vaccines. The present technique for preparing yellow fever vaccine by growth of the virus in the young chick embryo was developed in the Rockefeller Foundation laboratories. The material used to infect the embryos is a weakened form of virus, and injection into the embryos is made with living virus from another embryo-culture or from virus preserved in dry form. The embryo is inoculated through a hole (made with a dental drill) in the egg shell, which has been sterilised with an antiseptic such as iodine solution, and the eggs are then incubated for three or four days. The embryos in which the virus has now multiplied are removed from the egg

* The Rickettsiae are organisms intermediate so far as size is concerned between bacteria and viruses. Two serious diseases due to Rickettsiae are typhus and scrub typhus (mite typhus).



FIG. 3.—Dr. W. I. B. Beveridge of the Walter and Eliza Hall Institute, Melbourne, examines developing hens' eggs which have been inoculated with the virus which causes mumps. FIG. 4 (right).—Vacuum-drying vaccine samples. (Photographs by courtesy of the Australian News Information Bureau.)

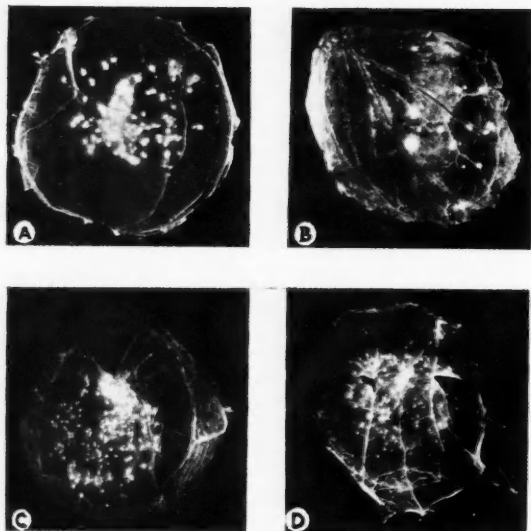


FIG. 5.—Appearance of chick-embryo tissue varies considerably from virus to virus and experts can often recognise the virus from the appearance of the tissue. The embryonic membranes (chorioallantoic membranes) shown here have been infected (A) with myxomatosis virus of rabbits (B) influenza A virus (C) B virus of Sabin and (D) louping ill virus. (From "The Cultivation of Viruses and Rickettsiae in the Chick Embryo", by Beveridge and Burnet.)

shells and then successively ground, filtered, frozen and dried. The vaccine is ready for use in vaccinating human beings after it has been tested to see that it is both safe to use and potent. Vaccination is carried out with the vaccine to which a carefully calculated amount of water has been added. The vaccine has proved very effective; in Colombia for instance, in the years 1937–1943, only one case of yellow fever was found to occur among 600,000 people vaccinated against yellow fever while 198 proven and 45 probable cases have occurred among unvaccinated individuals in the same region during the same period.

A similar method is used for preparing influenza vaccines. Dominion laboratories have contributed much to the development of large-scale techniques of producing these vaccines. Outstanding in this field is the Walter and Eliza Hall Institute in Melbourne which during the war perfected, in collaboration with the Commonwealth Serum Laboratories, a process which at pilot-plant stage proved capable of providing 1000 doses of influenza vaccine per day. Research director of the Institute is Dr. F. M. Burnet, who has collaborated with a colleague, Dr. W. I. B. Beveridge, in the writing of a valuable report entitled *The Cultivation of Viruses and Rickettsiae in the Chick Embryo* (Medical Research Council, Special Report Series No. 256) which the Stationery Office has just published.

Desert Air Force School of Science

To the general subject of the Services' experiments in the field of adult education DISCOVERY has devoted a good deal of space, in particular from the point of view of the Army, though the general burden of our comments would have applied with equal force to adult education in the other two services. One of the difficulties with which the organisers of adult education in the Army had to contend arose from the fact that while the army unit had to be used as the functional basis of educational organisation it was not necessarily the best basis for a comprehensive educational service. This point was emphasised by the Director of Army Education, Major-General Cyril Lloyd in two articles published recently in *Nature* (Vol. 158, pp. 775-780, pp. 821-823).

Because of the great differences that exist between different units, in each unit there was in effect a unique educational experiment. The level of educational achievement was affected by such factors as the size of the unit, the nature of its duties, the locality in which it was stationed, and the availability of instructors and teaching facilities, not to mention the attitude of the Commanding Officer. Statistics purporting to show the extent to which soldiers took advantage of the facilities offered tend to be misleading. There is the example of the Petrol Can Recovery Unit mentioned by Major-General Lloyd, which for months claimed 100% educational efficiency. The unit consisted of one officer and one other rank; the officer was taking a correspondence course in law and the other rank was attending a local technical school. For such reasons the qualitative picture is by and large more reliable than detailed statistics which almost inevitably tend to be reminiscent of the classic report made by the Medical Officer of a regiment stationed in India, who recorded that 50% of the teetotalers in the regiment had died within the period under review; it turned out that there had been two abstainers in the regiment, and one of them had been killed by a tiger!

Many of the experiments in Army Education were conspicuously successful. So too were many of those

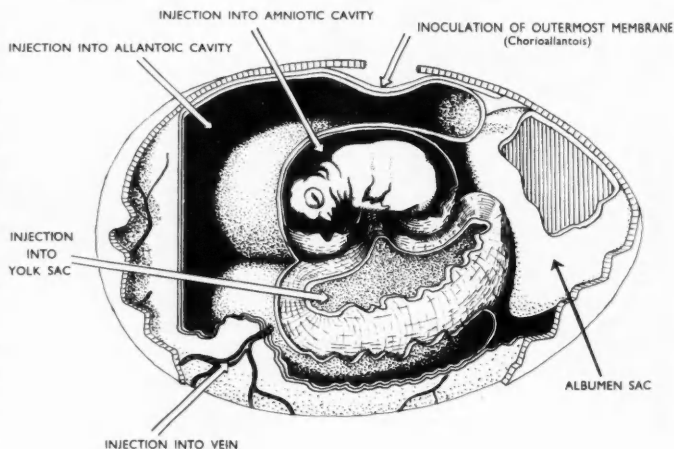


FIG. 6.—The chick embryo can be infected by a variety of routes. The main routes are shown in this diagram. Oldest and still most generally useful route is to deposit the virus on the outermost membrane (chorioallantois).

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made by the R.A.F. One outstanding success was the Desert Air Force School of Science, of which a reader has sent a most interesting description. The Desert Air Force was, of course, the air arm of the Eighth Army. After fighting its way from El Alamein to Tripoli and from Sicily to the northern plains of Italy, the Desert Air Force came to rest on the Friulian plain and established post-war headquarters in Udine.

Its nomadic existence over, Desert Air Force was able to expand its educational activities. The Educational and Vocational Training Scheme had then been in official existence for some time but the difficulties of operating it in overseas theatres of war were enormous. Among other things, the scheme aimed at providing classes which would prepare R.A.F. candidates for two special examinations—the War Educational Certificate and the Forces Preliminary Examination, the latter being approximately of matriculation standard. Given a qualified instructor, a sufficiency of suitable text-books and adequate classroom facilities, it is possible to teach such subjects as Modern Languages, Mathematics and History to almost any standard required; difficulties arise immediately, however, when Physics, Chemistry and Biology appear in the syllabus. The biggest difficulty is presented by a lack of special apparatus. Given time, many helping hands and *carte blanche* in the technical stores, an instructor could doubtless improvise a number of useful items, particularly in the field of electricity and magnetism, but things like optical benches, Geissler tubes and Kipp's apparatus are likely to defeat his ingenuity. Moreover he would need permanent quarters to house his apparatus—and it by no means follows that suitable accommodation will be available.

Thanks to a stroke of luck, the Desert Air Force found the solution to these difficulties almost before they arose. There existed in Udine a municipal institution that combined the functions of a grammar school and a technical college and served to prepare students both for the universities and for entry into commerce or industry. Part of this institution was known as the *Real Liceo Scientifico—Giuseppe Marinelli*. (The word *real* disappeared from its title after the dissolution of the monarchy; the Italians were punctilious in such matters.) The tuition offered to Italian students in the Liceo corresponded approximately to that received by children in an English grammar school who go on the 'science side' as opposed to 'arts' or 'commerce'—with one important difference. English children are normally afforded facilities for 'practical' work; most schools are able to provide sufficient apparatus and facilities to enable each pair of students personally to carry out a variety of experiments. This system is not common in Italian schools, probably because of their more stringent budgets. Practical work is carried out at the universities, but before this stage is reached students have to be content with demonstrations. As a result the demonstration apparatus is often more abundant and of higher quality than is usual in English schools.

It was of course open to the Desert Air Force to requisition such classroom facilities as they might require in the Liceo but matters were arranged much more satisfactorily and on a most amicable basis. The municipal education authority took the initiative and approached the Air Officer Commanding with an offer of accommodation at the Liceo Scientifico—an offer which was gladly accepted.

The facilities placed at the disposal of the Desert Air Force were as follows: a permanent office; use of a classroom, the physics and biology lecture theatres, the chemical laboratory, and complete freedom to use any piece of apparatus in the place.

Apart from an inexplicable lack of simple ammeters and voltmeters for electrical experiments (a gap that was easily filled from R.A.F. sources), the apparatus was gratifyingly complete. The physics and biology lecture theatres had accommodation for about thirty students. The former was equipped with an elaborate power-board which gave a number of useful voltages, both alternating the direct, at convenient points. The lighting was controlled by a four-way switch and a rheostat placed behind the lecturer's bench—a great convenience during optical demonstrations. The physics theatre was also equipped with an epidiascope and a 35-mm. film projector. The biology department was particularly well supplied with wax and plaster of paris models and with wall-charts—all of German manufacture. There were also a number of excellent preserved dissections and a good collection of microscope slides. The chemistry laboratory was rather small and would accommodate no more than about seven pairs of students. The usual reagents were available but many of them were running short as Italian sources had dried up completely. (This was easily remedied; the Air Force used what reagents they needed and replaced them as far as possible from R.A.F. medical stores.) Behind the chemistry laboratory was a store-room which, in addition to housing the laboratory glassware and the wall-charts, contained a Leitz research microscope, a Sartorius short-beam balance and an excellent collection of geological specimens and crystal models. The Air Force also made use of the services of the Italian laboratory assistant to whom an honorarium was paid.

The Desert Air Force School of Science opened under two N.C.O. instructors with classes in Physics, Chemistry, Geology and Elementary Biology. One instructor, however, was shortly afterwards repatriated and was not replaced. The remaining instructor, a Member of the Pharmaceutical Society, carried on alone, teaching Physics and Chemistry only. On the expiry of his overseas tour he was replaced by a graduate zoologist who, however, continued to teach Physics and Chemistry because of the greater demand for these subjects.

The classes were thrown open to all ranks of both Air Force and Army and at first the attendance was remarkably good. Later, however, the effects of the release programme began to be felt. There were many repatriations and few replacements, without any compensating reduction in the number of units. The result was that nearly all units were very much under establishment and could ill spare personnel who wished to attend classes. Another disadvantage (which applied to the E.V.T. Scheme in general) was that, owing to the constant flux of personnel within an area, it was unusual for an instructor to finish a course with the same pupils as those with whom he began it. Courses were made as short as possible, though this meant reducing their educational value in proportion. To cover the matriculation syllabus in, say, inorganic chemistry in a total of thirty-six hours' tuition does not permit of repetition or revision and calls for unorthodox teaching methods if anything at all is to stick in the students' heads.

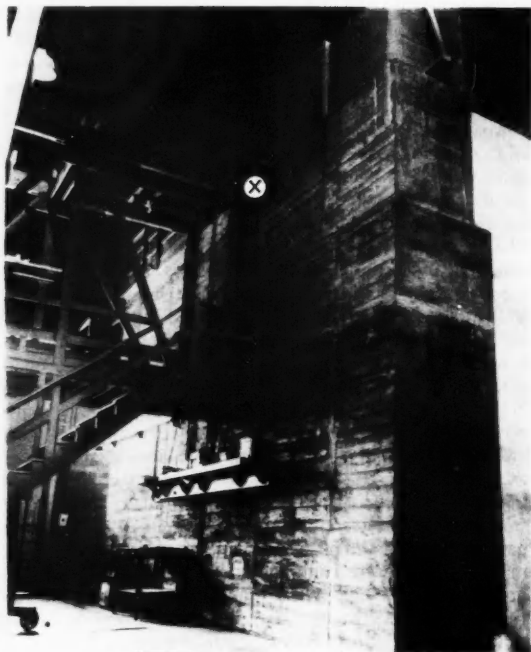


FIG. 7.—The first atomic pile—Chicago Pile No. 1, or C.P.1—was built on a squash court. It was soon dismantled because of the danger of radiation in a populous neighbourhood. The material from it was built into Chicago Pile No. 2 erected in the Argonne Laboratory a few miles outside Chicago; this pile, which is the oldest atomic pile in existence, is seen in the photograph. Above the pile is a laboratory. At point X a string (or stringer) of graphite blocks containing samples for irradiation can be inserted into the pile.

Nevertheless, the School of Science was a unique and worthwhile experiment in Forces education. The school was regarded as something of a showpiece and was visited by a number of important people touring the C.M.F. area. At least one eminent educationist expressed his keen pleasure at finding such a thing in what might well have been an educational wilderness.

"Were the Natives Friendly?"

THE problem of devising some international system of atomic energy control now passes for the time being from the Atomic Energy Commission to the Security Council. Here an attempt will be made to hammer out what appeared throughout 1946 to be political intransigence into something resembling unanimity, and the veto will again serve the function of the much overworked anvil. At this juncture it does not seem profitable to comment on what has so far transpired at Lake Success in this connexion. In real significance, what has happened in the Atomic Energy Commission will be eclipsed by what happens in the Security Council.

Taking a short holiday from serious comment on matters atomic, we think readers may be interested in an anecdote which comes from the atomic field. The anecdote emanates from Dr. Arthur H. Compton who was recently in Europe.

In December last the Americans celebrated the fourth anniversary of the beginning of the Atomic Age, which they held to begin on December 2, 1942, when the first atomic pile—the pile described in the Smyth Report—began to operate. On that date Dr. Enrico Fermi, who had directed the building of the chain reactor erected in the squash court on the campus of Chicago University, withdrew the control rods and set the pile working. Everything went according to plan and Dr. Compton relates how someone handed Dr. Fermi a bottle of Italian wine and a cheer went up. "The men in the suicide squad breathed an audible sigh of relief," said Dr. Compton. "I called James Conant at Harvard University on the telephone and spoke in our usual extemporaneous war-time code. 'The Italian navigator has just landed in the New World,' I said. 'Were the natives friendly?', Conant asked. 'Everyone landed safe and happy,' was the reply."

Soil Mechanics and Engineering History

CIVIL engineers have come to regard soil mechanics—the study of the behaviour of soils under loads and pressures—as an entirely new branch of engineering science, developed as the result of comparatively recent research. So far as practical application goes this is true; it is only during the last few years that soil mechanics has come out of the laboratory on to the construction site on a wide scale. In a recent paper to the Newcomen Society, A. W. Skempton of the Soil Mechanics Laboratory at the Building Research Station, who is one of the leading English authorities on the subject, has shown the existence of a soil mechanics pioneer of a century ago. He was Alexandre Collin (1808–90), a French civil engineer, who rose to an eminent official position in his own country.

But it was as a young man that his pioneer work was done. As a junior engineer on the Canal de Bourgoyne in the 1830's Collin was confronted by many large and expensive landslides in embankments, cuttings, and earth dams, and noted that these occurred where the soil was of a clay type. Clay had long been known as an unpredictable material, and no theory existed to account for its properties. In a series of minute and beautiful field observations Collin measured these slides, and found that in every case the mass of clay had moved forward bodily over a defined



FIG. 8.—The central control panel of Chicago Pile No. 2.

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surface, which he proved to have a constant cycloidal section. The then prevailing idea that clays behaved rather similarly to sands was not borne out by observed facts; what had happened was that the clay had failed in shear, and the whole mass had slid bodily forward over a deep 'slip surface' which he was able to represent as a cycloidal curve.

No such observations had previously been made, although mathematicians such as Coulomb (1773) and François (1820) had produced purely theoretical analyses of the behaviour of clay slopes. Collin proceeded to measure the actual shear strength possessed by the soils in question, and he devised a simple apparatus for the purpose identical in principle with that used in soil mechanics laboratories today. The strength of the clay having been *measured*, rather than assumed or merely neglected, the way was clear to a valid analysis of the forces that were really acting to cause the banks to slip, and Collin made it. He went on to point out that clays undergo a progressive loss of strength if their moisture content increases, and made measurements to confirm this. In 1846 he published his Memoir, setting out in great detail his observations and conclusions. This attracted little attention at the time, and lay forgotten in a few specialist libraries for more than seventy years.

Collin's pioneer observations were made just prior to a period when civil engineering was in process of becoming an academic science: a mass of engineering work was in progress, and trained young engineers were needed in ever increasing numbers. In 1855, Professor W. J. M. Rankine was appointed to the Chair of Civil Engineering at Glasgow, and his voluminous writings rapidly became the standard text-books for the remainder of the century. Among his productions was a theory of earth pressures, which, while it bore little relation to observable facts, enabled simple calculations to be made by the application of a formula. This gave results that usually worked in practice, and fulfilled a pressing need of the time. Together with other and similar theoretical analyses, it also became the delight of examiners in the many technical colleges then being set up.

However, as engineering works grew larger, spectacular failures of earth embankments, dock walls, and the like became more frequent. Even the application of a generous 'factor of safety' (defined later by Professor Sylvanus P. Thompson as 'the factor of ignorance') did not always prevent such disasters. Possibly the turning-point came with the construction of the Panama Canal, in which landslides on a huge scale occurred in the famous Culebra Cut, adding by more than one-seventh to the total quantity of excavation in the entire canal. The American engineers concerned dug Collin's Memoir out of its obscurity, and quoted extensively from it in their technical reports. Now, a hundred years after its publication, Mr. Skempton and the Newcomen Society have established its status as a pioneer piece of technological research.

Collin expressed the conviction that, while he had done no more than throw light on certain aspects of soil behaviour, others would come after him to produce a complete and rational solution. Such men, he says, would be those who "combine a knowledge of mechanics with the outlook of a natural philosopher". Modern soil

This Atomic Age

It is no longer the fashion to give children edifying books, but there is much to be said for handing them at a suitable age a *Lives of the Scientists* to take the place of the *Lives of the Saints* of a bygone age.—Noel Annan in *The New Statesman*.

Best shot in this disturbing but laugh-loaded short (18 min.) film—*Is Everybody Happy?*: Harvard's famed Ernest Albert Hooton gloomily winding up a deadpan lecture to an anthropology class: "Mechanised and moronic man moves toward extinction. . . . Any questions?"—*Time*.

The biggest problem is the almost universal shortage of manpower. This affects everything. There is far more work to be done than there are men and women to do it.—Government White Paper, *Statement on the Economic Considerations affecting relations between Employers and Workers*.

I venture to point out that there is a substantial reserve of labour which might well be transferred to industries engaged in making the goods we so urgently need. A conservative estimate puts the number of persons gainfully employed in the betting trade at 300,000 to 400,000.—B. Seebom Rowntree in a letter to *The Times*.

Hardly a month passes at the NAPT without our receiving a pathetic letter from some hopeful and courageous tuberculous patient who wishes to offer himself for experimental purposes. We have to tell him that, even were such a sacrifice permissible, it would be fruitless, because in this work we need not one but a hundred subjects.—*Bulletin of the National Association for the Prevention of Tuberculosis*.

Human subjects have been employed for many years to assess the value of certain types of potential chemical warfare agents and the efficacy of suggested defensive measures . . . hundreds of volunteers have been used in this way.—Dr. H. Cullumbine in "*British Medical Journal*".

mechanics is the embodiment of this principle—basing its theory on observed behaviour of soils and the precise measurement of their properties. It has provided a fundamental advance in civil engineering theory, which has rendered obsolete much mathematical theorising based on inadequate assumptions. Its outstanding pioneer has been Professor Karl Terzaghi, now of Harvard, whose standard work, *Theoretical Soil Mechanics*, was published in 1943. Few large civil engineering projects are started today without a detailed soil investigation, and active research continues in many countries. Notable work has been done in this country at the Building Research Station and the Roads Research Laboratories of the D.S.I.R., and a research laboratory has recently been opened at the Imperial College.

THE genetics controversy which was fought out in Russia in the 1930's and which centred around Vavilov and Lysenko divided international scientific opinion. Outside the U.S.S.R. judgments on the controversy were often coloured as much by political convictions as by consideration of the scientific facts. The confusion was made more confused by the fact that relatively little of the relevant literature had been translated. Now there has come available a trustworthy translation by Dobzhansky of Lysenko's book, *Heredity and Its Variability*, while additional information on the new Russian genetics is made available in the Imperial Bureau of Plant Breeding publication by Hudson and Richens. In this article Dr. Darlington considers the evidence and gives his verdict on the change that has come about in Russian genetics. He holds that the outcome of the Lysenko-Vavilov controversy is no less than the official overthrow of scientific truth in the genetics field.

A Revolution in Soviet Science

C. D. DARLINGTON, F.R.S., D.Sc.

SHORTLY after the Russian Revolution Lenin set to work to establish a system of scientific research. He was concerned that it should be of practical use but at the same time have sound theoretical foundations. With these ends in view, he set up the Lenin Academy of Agricultural Sciences with a young man, Nikolai Ivanovitch Vavilov, at the head of it.

Vavilov was a plant breeder educated partly in England, a pupil of William Bateson, and an energetic and original exponent of the new science of genetics. He began the organisation of the Bureau of Plant Industry throughout the Union. He undertook expeditions to Afghanistan, Abyssinia and Central and South America, and his collections put all our ideas of the origins of cultivated plants in a new light. They also enabled Soviet breeders to work with the best possible materials in improving the crop plants needed for the new agricultural development of their country.

Vavilov's work came to be applauded and imitated throughout the world. In the Soviet Union itself, however, his success gave rise to some doubts. There had always been a feeling that genetics, with its rigorous determinism and its consequent assumption of ineradicable race differences, was not entirely in keeping with the general line of Soviet ideology. A view much more convenient politically had been expressed by old-fashioned botanists in Russia whose liberal views had led them to support the Revolution. Such men as Timiriazev and Michurin, although their opinions on heredity had been discredited in scientific circles abroad, gave a much more hopeful view of what the environment could do in changing heredity. And, as Marx had said, it is not enough to understand things. We have to change them. Men in Moscow were beginning, under Stalin, to drink deeper draughts of the Marxist doctrine and it proved to have, as it was intended to have, the most intoxicating properties.

Complaints about genetics were brought to a head in a very odd way. An obscure worker on an agricultural research station in the Ukraine claimed that, by special treatments, which he had presumably heard of from German sources, wheat could be made to grow farther north. His claim gave birth to propaganda, probably on a larger scale than he had expected, propaganda which preceded instead of following the success of the treatment by

'vernalisation'. The treatment in fact led to nothing except that it put its discoverer into a position in which he thought he might safely claim that he could change heredity. How he did so we shall see later. Such was the beginning of the career of Academician Trofim Lysenko.

Lysenko alone would have been useless; but he chanced to fall in with a very active philosophical writer, of the name of I. I. Prezent. Together these two concocted a theory of genetics and this theory they presented in the correct Marxist terminology to a series of genetics conferences in Moscow and Leningrad. They presented it as an alternative to the western, bourgeois and clerical science of genetics as previously understood. The third of these conferences took place in 1939. It was completely successful. It was followed by the dismissal and death of Vavilov and his leading colleagues, and the appointment of Lysenko to his position as President of the Lenin Academy.

The meaning of these events has long been known to geneticists. The evidence, however, has not been readily accessible. The world is now indebted to Theodosius Dobzhansky, Professor of Zoology at Columbia University, one of the leading geneticists in the United States and a graduate of Kiev University, for the translation of a book by Lysenko which brings his theory up to date. This work was published in 1943 and circulated abroad in 1945, and again in 1946 bound with the author's collected articles in *Pravda*, under the title of *Heredity and its Variability*. It is a short book of some 25,000 words. It includes many repetitions and many obscurities but every word is worth reading by scientists outside Russia for these are the arguments, the ideas and the methods of the man appointed as the chief scientific director of Soviet Agriculture and a Vice-President of the supreme organ of a government which, we have been given to understand, attaches supreme importance to science.

Lysenko begins with these words:

Heredity as understood by followers of Mendel and Morgan. In all reference and text-books on genetics, heredity is understood merely as reproduction of like by like. In my opinion, such a definition gives little basis for understanding the phenomenon of heredity. Men have always known that wheat grows from wheat seeds and millet from millet seeds, etc. . . .

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Our conception of heredity. Our definition of the phenomenon of heredity differs from that which has been accepted in genetics up to the present time. We understand heredity as the property of a living body to require definite conditions for its life, its development and to react definitely to various conditions. We understand the term heredity as referring to the nature of the living body. . . .

The knowledge of conditions which are required by a living body, and of the reactions of that body to various conditions, amounts to a knowledge of its hereditary properties. Consequently to find the conditions of the external environment which are demanded by a living body (an organism) for the development of certain characters or properties will amount to investigation of the nature, i.e., of the heredity, of those characters and properties.

On this foundation (the italics are Lysenko's) the argument proceeds easily. Heredity is development. The environment can change development. Therefore the environment can change heredity.

Lysenko recognises the need for experimental evidence in support of this fundamental conclusion. "Comrade Solovey," he writes, "has, by means of autumn sowing, obtained a winter form from the spring barley 'Pallidum 032'." And again, "by vernalisation spring forms have been obtained from every standard winter wheat taken for experiment". Such statements by themselves, or from a trained geneticist, would be bound to arouse the greatest admiration. We have to remember, however, that Lysenko six years ago claimed to be able to revolutionise Russian wheats in three years by 'intravarietal hybridisation'*—a claim no longer mentioned in the present work. We also have to remember that Lysenko denies the existence of 'pure' lines and that the highest test of homogeneity† he applies is to take seeds of wheat 'from the same bag' (p. 47). In this light we can understand that the 'forms' and 'varieties' he works with are in fact mixtures such as are found in primitive agriculture everywhere. Using such 'varieties' it naturally follows that "with bad agro-technique one never can get good varieties from bad ones and in many cases even good cultivated varieties become bad in several generations".

When such 'forms' or 'varieties' are grown under extreme conditions (whether vernalised or not) they are at once exposed to selection and are rapidly changed in the well understood Darwinian way. The evidence as a whole shows that Lysenko is making use of the three classical precautions needed for the success of so-called Lamarckian experiments, experiments designed to prove the inheritance of environmental effects: namely beginning with a mixed stock, omitting to use proper controls, and repudiating statistical tests.

But it must not be supposed that any single or consistent fallacy runs through Lysenko's unfolding of his new science. It seems indeed unlikely that any fallacy known in the histories of science or of magic escapes Lysenko's grandiose mystification. But the prime evil lies not so much in fallacies (which are already well known in western



Nikolai Ivanovitch Vavilov (1885-?).

countries) as in the method of argument from authority which, on a kindly interpretation, might have overflowed from the *Pravda* articles. "Our Soviet science, the Michurinist direction in science, gives a clear understanding of the way in which the nature of organisms may be changed." The naughty Mendelian-Morganians on the other hand "disagree also with the Darwinian theory of the development of plant and animal forms". And again "the best biologists, Burbank, Vilmorin and particularly Michurin, have paid much attention to the practical significance of plant organisms with destabilised heredity". Clericals and reactionaries like Mendel and Johannsen wasted their time presumably with undestabilised heredity. "Darwin repeatedly emphasised in his work the usefulness of crossing and the biological harmfulness of self-fertilisation as a law of nature." The author has not heard of any post-revolutionary work outside Russia and so does not know that this law of nature was recently destabilised, if not liquidated. "A correct classification of the facts of behaviour of hybridisation was given by K. A. Timiriazev." Timiriazev was a Russian physiologist, friendly to the revolution, who died in 1920. He never made a hybrid in his life. "Facts available in Soviet agrobiological science permit the formulation of a single operational theory of heredity which fulfils the requirements of K. A. Timiriazev . . ." What the facts are we are not told. What the theory may be we are left to guess. But the requirement of Timiriazev is fortunately no other than that of William of Occam.

* That is, by making crosses between different plants of the same variety which should in wheat be identical.

† Uniformity of heredity.



Central figure in this photograph is Academician Trofim Lysenko, here seen lecturing to a group of visitors to the All-Union Agricultural Exhibition in Moscow.

Scholasticism goes of course with certain other signs of scientific decay. "An organism does not accept inferior food elements if superior ones are available," writes the physiological Academician. "The relative purposefulness, the adaptation, of the plant and animal world are brilliantly explained by the Darwinian doctrine of natural and artificial selection." Teleology unites with dialectical materialism, and natural selection is an equally good bedfellow with the inheritance of acquired characters. "If the surrounding milieu does not contain the conditions needed for the development of some characters and properties without which the organism cannot continue to exist, such characters and properties cannot easily remain recessive. They develop perforce, so to speak because otherwise the organism must cease to exist." Apparently it would not be dialectically sound for a well-bred organism to cease to exist, so to speak. We could not help admiring the effrontery, were it not unconscious, with which the language of dialectical materialism is given a mystical content in a country where many men have been damned for philosophical heresy by Lysenko himself. "The normal internal contradiction of life, the life impulse, is created and from time to time renewed in the plant and animal worlds largely through crossing, fertilisation, sexual union of plant or animal forms at least slightly differing from each other."

A robust anthropomorphism is seen in such arguments as: "If plants and animals possessed infinite individual lives they would, speaking crudely, be in torture during all their lives", or at least, one must suppose, in their old age. However, even according to Lysenko's theory, sexual union is not accomplished without pain, for the dominant

eats and digests its recessive allelomorph and belches it up later to give segregation. In spite of this 'assimilation' we learn that "The double heredity gives rise to a greater viability of the organisms, and to their greater adaptation to varying living conditions."

It is strange amongst all this fictional writing to find Lysenko devoting a page to a description of chromosome behaviour as it was understood before the Russian revolution—no doubt taken out of an early work by Morgan. In this he is hardly behind some of our universities but the reader is left wondering whether Lysenko believes this account has anything to do with heredity or not, in view of his extraordinary notions about statistics for, as everybody knows, statistics is a key to Morgan as well as to Mendel. He concludes:

The Mendelians foist this 'pea law', according to Michurin's happy expression, on the whole of living nature. But in reality it is basically wrong even for pea hybrids, including the factual material obtained by Mendel himself. The progenies of different hybrid plants varied even in Mendel's experiments much beyond the ratio 3:1. Thus, in the offspring of one plant there were 19 yellow and 20 green seeds, and of another plant—only a single green for 30 yellow ones.

Lysenko here seems to attach value, if not to sound statistics, at least to plausible numbers but elsewhere in the Proceedings of the Soviet Academy of Sciences he has demonstrated by irrefragable dogma that statistics have nothing to do with the case.

Many years of obedient and recently unanimous applause have given Lysenko an audacity which is bound

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to astonish the unprepared reader. It was in 1911 that Erwin Bauer, a Mendelian geneticist, showed that mutations in vegetatively propagated plants made them genetically mixed. A skin of the mutant propagated itself permanently over the original type of flesh, or vice versa. Chimaeras arise in this way in many, perhaps in most, old cultivated clones and it was a minor success of great practical interest when Asseyeva, one of Vavilov's school (in 1927) showed that many potato varieties were chimaeras. If adventitious buds were grown after the eyes had been cut out the new shoots would be free of skin and different from the typical variety. Lysenko quotes this fact. He quotes it four times—for him a moderate degree of repetition—as though it were his own discovery. He quotes it to prove four different things but first and foremost to show that:

The assertion of Mendelian-Morganian geneticists that all the cells of an organism possess the same nature, the same heredity, does not stand criticism.

Asseyeva might have made an interesting comment. But Asseyeva is no longer there to reply.

One of the sacred authorities to whom Lysenko pays homage is that 'talented Russian genius', Ivan Vladimirovich Michurin, who died in 1935 in the town now known as Michurinsk. Michurin was an importer of plants who, like the American, Burbank, accounted for many of his introductions as the results of his own remarkable success in hybridisation. His motto was: "We cannot wait for nature to grant us favours: it is our business to take them from her." Again like Burbank he took the favours and having done so he supported his claims to originality by a theory that extraordinary hereditary improvements could be made in plants by special tricks of ageing or grafting. This view finds no support in the 2,000 years of grafting experiments carried out before Michurin's birth chiefly outside Russia, and it is much easier to suppose that he got his best plants from Canada and the United States. Nor are our suspicions lessened by the statement that in certain crosses "it is preferable to use pollen of a young plant in its first year of flowering the nature of which has not yet become strong".

Michurin's theories, however superstitious to us, fit in very well with Lysenko's environmentalist propaganda and the general political trend in Soviet Russia. That is why today we learn that "Since Michurin's death his work has been continued not only by great scientists in selection and by various institutes but also by thousands of small laboratories set up in villages throughout the country. The huge army of Michurin experimenters form the vanguard of socialist agriculture."*

When we recollect that Michurin recommended the use of mixed pollen and that Lysenko finds no objection, on his digestion theory, to hybrids being purely maternal we cannot be surprised to learn that "fruit-bearing hybrids have been produced in Michurinsk as hybrids of apple and pear trees, plum and peach, cherry and plum, red and

black currants". Doubtless the production of these hybrids was part of the year's plan of research and the plan was fulfilled. How fortunate that the hybrids proved to be fertile!

It is of great interest to western observers to notice that, as the practical success of the Lysenko and Michurin schools becomes more demonstrably lacking, their claims to future success grow larger and their claims of Marxist purity and their denunciations of bourgeois and fascist science become more vociferous. We may learn a great deal in studying these claims from the examples of Titus Oates and the late Dr. Goebbels, or the South Sea Bubble and the Dreyfus case, historical figures and incidents normally outside the scientific curriculum. We may even, thinking of Russia, recall Rasputin. Those who have been privileged to hear Academician Lysenko rant and roar have compared him with Hitler. Certainly in manner and matter the literary works of the two masters bear some resemblance.

The Russian story is in fact as tragic as any of these names can suggest. It is one not to be remedied merely by the exposure of a few charlatans. The leading Russian geneticists (apart from those who have taken refuge outside Soviet-controlled countries) have been 'liquidated' in the course of this long political intrigue. These are no longer questions that can be argued about in Russia. They have been decided. All those who were prepared to argue have been put away.

Not only science but the people have paid. In the revolutionary campaign to produce a socialist agriculture whose scientific basis we now see the Russian people have made terrible sacrifices. *Delirant reges, plectuntur Achivi.*

We see indeed the official overthrow of truth and reason and of the men who stood by them in one branch of science. This overthrow is no less official than that in Hitler's Germany. It affects first and foremost the same branch of science, that concerned with heredity, race, and class. The reason is merely that this is the science of greatest political moment under the conditions of social stress in the world today. The implications of this situation reach beyond the scope of the present review. But men of science everywhere will do well to ponder them.

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* Professor Paul N. Yakovlev, Stalin Prize Winner and Manager of the Michurin Nursery Gardens, in the Voks 7.8 U.S.S.R. Bull. Soc. for Cult. Relation with Foreign Countries, 1945, p. 51.

The Chemical Society of London

TREVOR I. WILLIAMS, Ph.D.

ON July 15–17 the Chemical Society is to celebrate the centenary of its foundation. These celebrations should rightly have been held on February 23, 1941, the hundredth anniversary of the inaugural meeting, but at that time the war did not allow more than formal recognition of the event. This year's celebrations will be immediately followed by the Eleventh International Congress of Pure and Applied Chemistry, also delayed since 1941, and the double event will bring to London distinguished chemists from all parts of the world. Indeed, if all those invited are able to attend, we shall see in London in July 1947 perhaps the greatest international gathering of chemists that will ever have taken place. The present is therefore a most appropriate time to review both the history of the Chemical Society itself and also some of the more outstanding of the great advances made in chemistry during the past century.

The Chemical Society of London rightly claims the distinction of being not only the first society ever formed solely for the study of chemistry but also of having proved so successful as to have been accepted as a model by Continental chemists. The French Chemical Society was founded in 1857, and the Berlin Chemical Society not until 1868.

Numerous factors contributed to the formation of the Chemical Society in 1841, but to understand most of these it is necessary to consider the history of chemistry in Great Britain for a number of years previous to that date. The teaching of chemistry was then conducted chiefly in the medical schools and little chemical instruction was obtainable at public institutions. The academic qualification of many of the leading chemists was the M.D. degree; fifteen of the original members of the Chemical Society were so qualified. Most working chemists obtained their practical training largely by working as pupils of, and assistants to, those who had already become proficient. The results of investigations in pure chemistry were generally communicated to the Royal Society, or to local philosophical societies, and were published in the transactions of these societies or in the *Philosophical Magazine*. One of these early societies—the Mathematical Society of Spitalfields—had a particularly close connexion with the Chemical Society. The Mathematical Society was formed in Spitalfields some time in the late eighteenth century (probably 1788) and, despite its title, the society often considered matters of purely chemical interest. A substantial proportion of the members were French Huguenot refugees engaged in the silk trade, who doubtless imparted to the society some knowledge of the important chemical research being conducted in France by Lavoisier and others. Robert Warington, who later became the first secretary of the Chemical Society, was a member of the Mathematical Society and so were many others who joined the Chemical Society at, or very shortly after, its inauguration. The Spitalfields Mathematical Society came to an end in 1845. Its nineteen remaining members became members of the

Astronomical Society, which also took over the library and other property of the old society. Many years later some of the chemical books in the old library were presented by the Astronomical Society to the Chemical Society and these thus provide a material link between the latter and the Mathematical Society.

By 1841 chemistry and physics, which had hitherto always been studied together, had each acquired sufficient individuality to stand alone. Chemistry in particular had received a great stimulus by the work of Liebig at Giessen, whence several young British chemists had gone to study. Among these young men was Lyon Playfair, who gained a reputation as the greatest scientific agitator of his time. It was he who shocked the calico printers of Manchester by telling them that their business would profit if they studied Dalton's 'Atomic Theory'. Though the hard-headed Mancunians never had much liking for his theories, they very quickly saw the importance of his demonstrations, and in consequence made several improvements in methods of dyeing and other processes connected with textiles. Playfair became, too, the great British exponent of Liebig's investigations in physiological and agricultural chemistry. It is not surprising therefore that Playfair took an active part in the formation of the Chemical Society and was one of the original members.

Another factor which made a considerable, and perhaps surprising, contribution to the foundation of the Chemical Society was the introduction of the penny postage in 1840. This undoubtedly gave a considerable impetus to attempts at all kinds of organisation which required much correspondence.

By 1841 there was a real need for the formation of a chemical society in Britain and it is fortunate that there was available at the same time a man who not only realised the existence of this need but had also the perseverance and the opportunity to see that such a society was formed. This man was Robert Warington. At the beginning of 1841, and possibly earlier, he began an active canvass among London chemists and lecturers to discuss their views on the formation of a chemical society. Finding the response very favourable he applied to the Council of the Royal Society of Arts, which included chemical subjects among those it discussed, for permission to hold a preliminary meeting in their rooms. This permission being "acceded to in the handsomest manner" a meeting was called for February 23, 1841. The chair at this meeting was taken by Professor Thomas Graham.* A provisional committee was formed to give effect to the meeting's resolution "That it is expedient that a Chemical Society be formed." Robert Warington was

* Graham was then professor of chemistry in University College, London, having previously been professor in the Andersonian Institution of Glasgow. He is best known for his work on the diffusion of gases and liquids—where his results are summarised in the well-known Graham's law—and on the process of dialysis.

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elected Hon. Secretary *pro. tem.* and, on subsequently being confirmed in this office, served until December 1851. The selection of the first President caused some difficulty. Michael Faraday was first approached but declined the honour on the grounds of the prior claims of his research. The nomination of Faraday, whose main researches were carried out in the field now defined as physics, is, incidentally, an indication of the closeness of the connexion still existing between chemistry and physics. Faraday did, however, join the Society during its first year and his association with it is commemorated by the Faraday Lectureship, founded by the Society in 1867, five months after his death. An invitation to deliver a Faraday Lecture is the highest honour the Chemical Society can confer; the 1947 lecture is to be delivered by Sir Robert Robinson, President of the Royal Society.

On Faraday's refusal the name of Richard Phillips is believed to have been put forward, as well as that of Sir J. F. W. Herschel. The final choice was, however, Thomas Graham, who had taken so active a part in the formation of the society. The leaders of the new society were Graham and Warrington, and among its most treasured possessions is the original Obligation Book, which is still signed by new Fellows on their admission and contains as its first signatures the names of these two pioneers.

The original members of the Chemical Society numbered seventy-seven; membership now exceeds 6000. The Society received its first Royal Charter in 1848. At the first General Meeting on March 30, 1841, it was resolved that "the Society shall consist of Ordinary Members, Foreign Members, and Associates". The decision to include Foreign Members was of great importance for it contributed much to the international outlook which has always been characteristic of the Society. It has, for example, brought to the Society as Faraday Lecturers men of such international distinction as Dumas, Cannizzaro, Mendeléef, Ostwald, Arrhenius, Bohr, Debye and Langmuir.

Until 1857 the Chemical Society used to meet at various temporarily rented premises in London but in that year it was transferred to Burlington House, Piccadilly, where it still remains, together with several other learned scientific bodies.

A Century of Chemical Advance

Although the Chemical Society was formed in response to a growing interest in chemistry, the early years of its existence were not marked by spectacular work in Britain. It was rather a period of consolidation, a process which was to prove invaluable in providing firm foundations for the great discoveries which lay ahead. Particular attention was paid to methods of inorganic and organic analysis. The dominant idea was the determination of the empirical

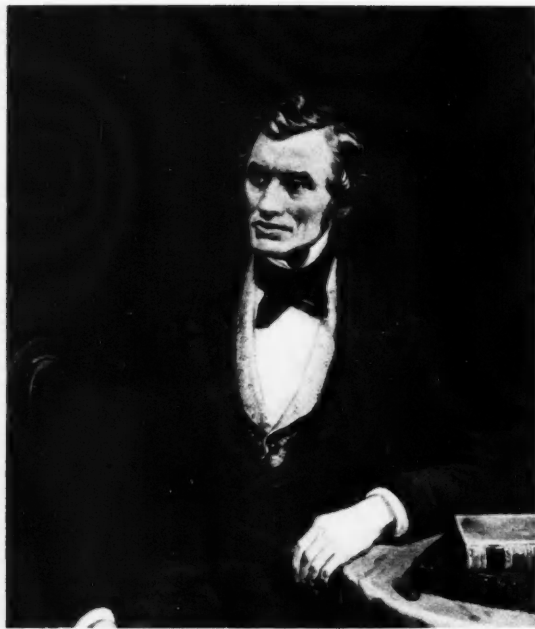


The opening page of the Society's Obligation Book. The first two signatures are those of Robert Warrington and Thomas Graham, who played an outstanding part in the founding of the Chemical Society.

composition of substances and the preparation of new compounds, the existence of which Dalton's Atomic Theory predicted. The leading chemists were Graham, Sir Robert Kane of Dublin, and Johnston of Durham. Graham was publishing a series of papers on the constitution of salts. Kane was making contributions to many branches of science, but perhaps his best known paper was on the chemistry of archil (a purple dye derived from lichen) and litmus. Johnston was primarily an agricultural chemist, though he also did much work on the constitution of minerals and of resins.

One branch of applied science, now an integral part of daily life, was, however, making rapid strides. This branch was photography. From about 1835 onwards Fox-Talbot, Herschel, Hunt, and others were investigating the chemical effects of light and were applying the knowledge so gained to the development of practical photographic methods.

An interesting controversy of the time was that occasioned by S. M. Brown's claim to have converted carbon into silicon. Though eventually demonstrated to be a result of poor experimental work—the alleged silicon proving merely carbon in a very incombustible state—even



Professor Thomas Graham, the Society's first president.

Liebig was sufficiently impressed to have attempted repetition of Brown's experiments.

The first years of the existence of the Chemical Society were notable for the publication of several text-books of chemistry, among which that of Thomas Graham (1842) was outstanding. Henry, Brande, and Kane also wrote books which passed through many editions.* It is interesting to note that only a century ago the whole field of chemistry could be adequately summarised in a text-book of quite moderate size.

Synthesis of Organic Compounds

Organic chemistry began to receive the serious attention it deserved only about the middle of the nineteenth century. Wohler's preparation of the typically organic compound urea from the essentially inorganic ammonium cyanate in 1828 was an event of great importance and struck the first blow at the conception of 'vital force' as a mysterious component of all organic compounds. Synthetic organic chemistry, today of such immense importance, is generally regarded as dating from 1853, when Berthelot began his syntheses of glycerides and fats. Synthetic work quickly became of practical as well as of theoretical importance. Investigation of vegetable products led to the development of processes for manufacturing such substances as methyl salicylate (active principle of oil of wintergreen), alizarine, and indigo. Perkin's synthesis of mauve in

* Henry's name is remembered in Henry's law, relating to the solubility of gases; Brande was a friend of Sir Humphry Davy and succeeded him in the chair of chemistry at the Royal Institution; Sir Robert Kane, an Irishman who became president of the Queen's College, Cork, was among the many chemists whose academic qualification was a degree in medicine.

1856 by the oxidation of an impure sample of aniline—one of the fortunate accidents of chemistry—laid the foundation of the aniline dye industry and of the synthetic dyestuff industry generally.

Dissociation Studies

In the field of physical and inorganic chemistry the study of dissociation was a particularly fruitful one. Sir William Groves, an original member of the Chemical Society, described observations on the thermal dissociation of water vapour as long ago as 1846. This particular instance of dissociation has since been studied by many other chemists, including Bunsen and Hinshelwood. The hydrogen-oxygen reaction, universally accepted by writers of elementary text-books as a model of chemical reaction, is now recognised as one of very great complexity. (This reaction is indeed the subject of a very extensive monograph by Professor C. N. Hinshelwood, the present President of the Society.) Perhaps the most outstanding aspect of thermal dissociation was however the development of spectral analysis by Bunsen and Kirchhoff in 1859. This great discovery might well have been made by Sir William Groves, for he had noted that when ignited in the 'voltaic arc' different metals show different spectral lines. He himself stated that if he "had had any reasonable amount of wit (he) might too have seen the converse, viz., that by ignition different bodies show in their spectral lines the materials of which they are formed". However, that thought did not occur to him, and the discovery of the spectroscopy was made by others. The spectroscopy proved of great value not only for chemical analyses in the laboratory but also, for the first time, permitted precise examination of the composition of celestial bodies. The study of ionic dissociation in solution also proved a most fruitful field of research.

Classification of Elements

The early decades of the Chemical Society's history saw too the discovery of many new elements and the classification of all known elements within the Periodic Table. Although credit for the latter must go to the Russian chemist Mendeléef, other chemists, including many Fellows and Foreign Members of the Chemical Society, did notable work in the same field. Dobereiner, Pettenkofer, Cooke, and De Chancourtois discovered certain simple numerical relationships. A great step forward was made by the English chemist Newlands, whose classification in 'octaves' came close to the classification adopted by Mendeléef. The periodic classification of the elements was not only of great practical convenience but also later proved of great importance in studies on atomic structure.

Another very important phase of chemical work was in stoichiometry—the quantitative study of the combination of elements. This was of fundamental importance for the exact determination of atomic weights and for the development of the conception of valency. With the clarification of ideas on the nature of valency came studies of the phenomenon of isomerism, to which Pasteur, with his extraordinary versatility, contributed so much.

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Portraits of past presidents line the walls of the Society's Lecture Room where so many important chemical discoveries have been announced.

what is today one of the most important branches of chemical industry—the production of artificial fertilisers. (The early Rothamsted experiments, it is interesting to note, were financed out of the profits from Lawes's patent process for manufacturing superphosphate.)

X-rays and Atomic Structure

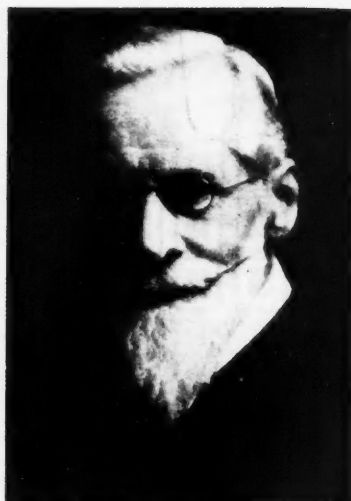
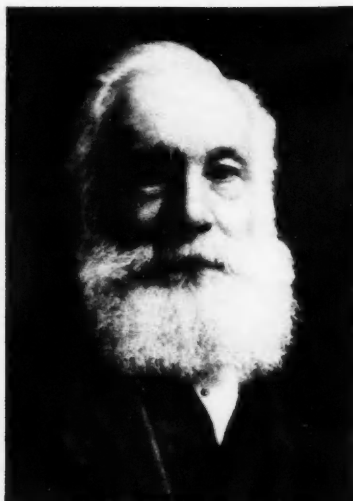
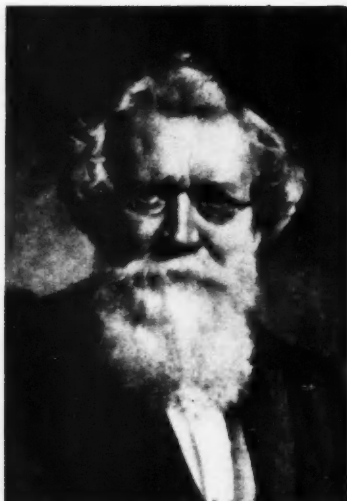
The year 1891 was of significance to the Chemical Society not only because it marked the completion of fifty years of very active work but also because it virtually marked the end of a chemical era. Five years later Becquerel's discovery of radioactivity marked the beginning of a new age in which the development of chemistry became increasingly influenced by studies of atomic structure. Much of the work of the preceding half-century could be attributed to Dalton's elegant and simple exposition of the atomic theory; thereafter, however, a more precise atomic theory which took account of the internal structure of atoms began to grow up.

It is of interest to recall certain prophecies made at the time of the Jubilee celebrations in 1891. Sir Lyon Playfair, as one of the five original members then surviving, was asked to address the Society. In the course of this address he states: *With regard to the elements, we are beginning to doubt what they are, and even to hope for their resolution . . . we may hope that during the next fifty years there will arise a chemical Newton, who may bring under one general*

law the motions of atoms, and even the rupture of those which we now call elements. This remarkable prediction has been amply fulfilled during the second half-century of the Society's existence, and it is indeed a not inadequate summary of the main trend of chemical research during that time. Another speaker on this occasion was the Marquis of Salisbury, one of the few scientific Prime Ministers this country has had; he commented on the work of Gilbert at Rothamsted and remarked, "I trust that the chemistry of the future may tell us why we have to go to Chile, and why we cannot take them (fertilisers) from the air around us." This problem, of immense economic importance, and now of special significance in view of the present shortage of food throughout the world, has also been solved. The establishment of the synthetic fertiliser industry has been one of the major practical achievements of chemistry during the second half-century of the Chemical Society's existence.

The acceleration in chemical research during the past fifty years has been remarkable. The speaker chosen to summarise the achievements of chemists at this year's centenary celebrations will have a task many times harder than that of Professor Odling, who summarised the history of the Society at the Jubilee celebrations in 1891. Here it is possible to mention only a few of the most outstanding results.

The emphasis of science has come to be laid increasingly upon atomic structure and it should be remembered



On this page are reproduced the portraits of six presidents of the Chemical Society. Above, from left to right: August Wilhelm von Hofmann, Sir William Perkin, and Sir William Crookes.

that though much of the knowledge gained in this field has been gained by physicists their work has been supplemented by, and indeed often dependent upon, that of chemists. The process used for the preparation of the plutonium necessary for the atomic bomb, for example, was based on micro-chemical research of the highest order. The solution of problems of valency and of the theory of reactions between atoms have resulted from the work of chemists, among whom N. V. Sidgwick (twice a Faraday Lecturer of the Society) is outstanding. The separation of isotopes of the elements, and indeed much of the evidence for their very existence, has come from chemical research. The analysis of the structure of crystals by X-rays or by electron diffraction methods, has been undertaken by both chemists and physicists.

The discovery of the so-called inert or rare gases—helium, neon, argon, krypton, xenon, and radon—by Sir William Ramsay in 1894 was of both theoretical and practical significance. From the theoretical point of view it was important in throwing light on certain problems of atomic structure and valency; more recently the study of the properties of liquid helium has led to results of fundamental importance. From the practical point of view the rare gases are of great importance to the illuminating industry, both for neon and other discharge tubes and for the gas-filled tungsten-filament lamp. More recently the chemist has made another major practical contribution to the lighting industry by providing the fluorescent substances used in the luminescent lamps which are now so rapidly gaining popularity.



(Left) Sir Henry Roscoe. (Centre) Sir Robert Robinson, present president of the Royal Society, and president of the Chemical Society in 1941, its centenary year. (Right) Professor C. N. Hinshelwood, present president of the Chemical Society.

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THE PRESIDENTS OF THE CHEMICAL SOCIETY

	Years of office		Years of office
T. Graham	1841-1843	A. G. V. Harcourt	1895-1897
A. Aikin	1845-1847	J. Dewar	1897-1899
W. T. Brande	1843-1845	E. Thorpe	1899-1901
R. Phillips	1847-1849	J. E. Reynold	1901-1903
C. G. B. Daubeny	1849-1851	W. A. Tilden	1903-1905
P. J. Yorke	1851-1853	R. Meldola	1905-1907
W. A. Miller	1853-1855	W. Ramsay	1907-1909
	1855-1857	H. B. Dixon	1909-1911
L. Playfair	1857-1859	P. F. Frankland	1911-1913
B. C. Brodie	1859-1861	W. H. Perkin (jun.)	1913-1915
A. W. von Hofmann	1861-1863	A. Scott	1915-1917
A. W. Williamson	1863-1865	W. J. Pope	1917-1919
	1865-1867	J. J. Dobbie	1919-1921
W. de la Rue	1867-1869	J. Walker	1921-1923
	1869-1871	W. P. Wynne	1923-1925
E. Frankland	1871-1873	A. W. Crossley	1925-1926
W. Odling	1873-1875	H. B. Baker	1926-1928
F. A. Abel	1875-1877	J. F. Thorpe	1928-1930
J. H. Gladstone	1877-1879		1930-1931
H. E. Roscoe	1880-1882	G. G. Henderson	1931-1933
J. H. Gilbert	1882-1883	G. T. Morgan	1933-1935
W. H. Perkin	1883-1885	N. V. Sidgwick	1935-1937
H. Müller	1885-1887	F. G. Donnan	1937-1939
W. Crookes	1887-1889	R. Robinson	1939-1941
W. J. Russell	1889-1891	J. C. Philip	1941-Aug. 1941
A. C. Brown	1891-1893	W. H. Mills	Aug. 1941-1944
H. E. Armstrong	1893-1895	W. N. Haworth	1944-1946
		C. N. Hinshelwood	1946-

There are indeed few aspects of modern life to which the chemist has not made some contribution, often a very substantial one. In the medical field the discovery of the sulphonamides, penicillin, paludrine, new anaesthetics, and many other drugs has been made by chemists collaborating with medical men and other specialists.

In the production of food the chemist has provided not only the fertilisers essential for modern systems of intensive cultivation but also a variety of substances for destroying pests. Among the latter may be mentioned the weed-killer, methoxone, and the insecticides DDT and Gammexane. (It is noteworthy that hexachlorocyclohexane, of which Gammexane is the *gamma* isomer, was first prepared by Michael Faraday as long ago as 1825, though its insecticidal properties have only relatively recently been discovered.)

Chemical research has not only improved the methods used in old industries but it has also created many new ones. Plastics, with all their extraordinary variety of properties and uses, form a typical example. A new and interesting branch of the plastics industry, which owes much to the persevering researches of Professor Kipping and his colleagues at Nottingham, is the production of the so-called silicone resins, which have remarkable heat-resisting properties. The plastic polythene, a remarkable electrical insulator, played a vital role in the development of radar during the war. The petroleum industry too, which is with coal the backbone of modern transport, could never have developed to its present enormous extent without the assistance of chemical research. Another major industry, the textile industry, has benefited in many ways from the attention of chemists. Chemical treatments have given existing textiles qualities, such as resistance to mildew and ability to withstand heat, which they do not possess in

their natural state. Besides this, totally new synthetic textiles, such as rayon, nylon, and Ardil, have been introduced. Synthetic dyestuffs have made possible the production of attractively coloured fabrics at prices within the reach of everyone.

To all these advances in chemistry Fellows and Foreign Members of the Chemical Society have made almost innumerable contributions, which may be found recorded in the society's publications. The latter now include the *Journal of the Chemical Society*, the *Annual Report*, and the *British Chemical and Physiological Abstracts*. The bound volumes of these are standard works of reference and are used throughout the world.

One of the Society's most valuable amenities is its library, founded in 1860. Today it contains some 47,000 volumes and it is growing at the rate of several thousand volumes a year. It is indeed rapidly outgrowing the space available, and parts of almost all the rooms in the building are now being used for storing books which cannot be kept in the library itself. The society is therefore anxiously seeking means for its extension.

The main purpose of the Chemical Society has always been the advancement of chemistry as a science, and the main methods used to achieve this end have been the holding of meetings for the communication and discussion of new discoveries, by the publication of papers on chemical subjects, and by the establishment of the library.

When it was first formed it was the intention of the society to create a chemical research laboratory but this intention was never fulfilled, chiefly through lack of funds and suitable accommodation. Research has, however, been fostered by making grants to individual workers. This scheme was started in 1868 and at present about £700 is devoted to it each year.

The first article by Dr. W. D. Evans on opencast mining in Britain was published in our December 1946 issue and dealt with outcrop ironstone. His second article is devoted to the mining of outcrop coal, which provides around 20 million tons of coal a year.

Outcrop Coal

W. D. EVANS, Ph.D., M.Sc., A.Inst.M.M.

THE sudden demand in 1941 for an increase in the home output of coal coincided with a shortage of skilled miners to man the existing collieries. Several collieries had closed down at the outbreak of war, so alternative sources of supply had to be devised. This led to the application of opencast methods to the working of near-surface seams of coal. At first it seemed that the coal industry had been wise in considering outcrop coal as a vanished asset. In the early days of mining in this country near-surface seams of coal were worked extensively from open pits, or from adits driven in from the outcrop of the seam. Fortunately, the possibility of suitable sites remaining in our coalfields was investigated by the Geological Survey on behalf of the Directorate of Opencast Coal Production, for it was found that the 'old men' had spared an unexpected amount of near-surface coal in many places. The Yorkshire coalfield, the Notts.-Derby coalfield and those of the Midlands proved amazingly fruitful; and in addition suitable sites were found in South Wales, Lancashire and Scotland.

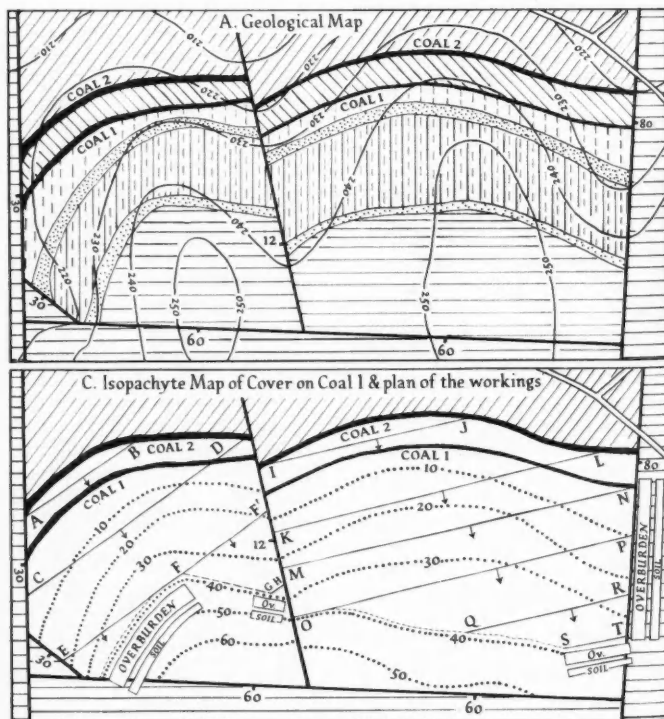
At the outset, this great war-time project was severely handicapped by a shortage of mechanical excavators suited to the working of outcrop coal. In addition, hastily devised plans for certain of the sites led to outputs far below what was anticipated. Inadequate prospecting failed to reveal the presence of old workings, and much time and money was wasted on sites which merely contained pillars of coal left behind in the old near-surface mines. Whilst criticism on these lines can be levelled at this venture, it must be borne in mind that, despite these set-backs, the Directorate of Opencast Coal Production was responsible for producing over 7½ million tons of coal by the end of April 1944 and well over 18½ million tons by the end of the war. Equally important is the fact that this substantial tonnage of coal was produced by mechanical excavators, and with manpower largely unskilled in mining.

Careful Planning Necessary

The opencast mining of coal is far more difficult than the strip-mining of the bedded ironstones in eastern England, for the geological structure of our coalfields is infinitely more complex. It is rare to find large areas of coal dipping evenly into the ground in the same way, and to the same degree, as the ironstone beds; the seams usually dip steeply into the ground and are often folded or

dislocated by powerful faults. Consequently, opencast coal sites have to be planned more carefully than ironstone pits; but the nature of the planning, and the mining technique employed, is similar for both types of opencast working.

In many cases throughout the coalfields this has not been recognised sufficiently, so that a decrease in the anticipated output of coal has resulted. For example, lack of planning in the working of sites containing two seams of coal has often resulted in excavated overburden being dumped on ground still containing workable coal. In addition, faulty pit-design has sometimes led to the workings becoming flooded with water, and the coal contaminated by debris falling from the overburden or slumping into the pit from the dumps of excavated material ranged alongside the bared bench of coal. When such sites have been systematically explored and the mining operation fully planned from start to finish, continuous output can be maintained even in pits working two seams of coal simultaneously.



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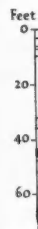
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Restoration of Farm Land

Also it should always be possible to incorporate restoration of the worked-out areas into the mining operation so that the land can be restored to agriculture soon after work has ceased. How this end may be achieved can be understood from the following example. In the site shown in the geological map (Map A) two seams of coal were worked simultaneously. The seams are slightly folded, but in general dip to the south; they are dislocated by faults ranging in throw from 12 to 80 feet.

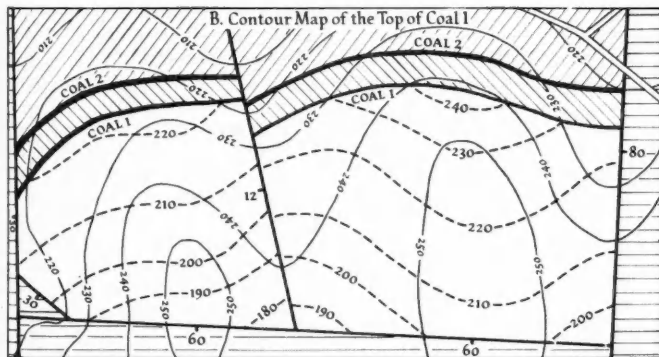
Trenches were dug at suitable points selected by the geologist, and samples taken from the seams were analysed. The coal in both seams was found to be of workable quality. A series of boreholes was then put down to check and supplement the data given by the geological map of the site. The level of each borehole was taken, and the beds proved by them carefully recorded. From these data an isopachyte map (Map C), showing the distribution of equal thicknesses of cover, was constructed. It was considered that the maximum thickness of overburden which could be removed economically was 40 feet with machinery available. The presence of two beds of sandstone in the overburden (see Map A) prevented the use of scrapers for removing the overburden. Further, the three faults throwing down the beds 30, 60 and 80 feet on the west, south and east sides of the site delineated the workable area of coal. The small NNW.-SSE. fault downthrowing the seams 12 ft. on the west was considered to divide the site into two parts for the opencast operation.

In order to provide a constant slope for drainage, as the

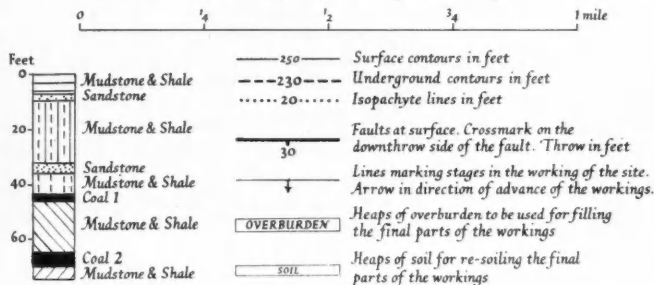
boreholes indicated that the beds were saturated with water, a dragline was used (to excavate the initial gullet) in the lower seam between *A* and *B* (Map C). The material stripped by this dragline was transported to a reception area near the line *E-F* (one of the limits to the workings) until sufficient had been accumulated to fill the open pit which would result when this part of the site had been worked out. The coal bared in this way down-dip from the line *A-B* was excavated by a back-acting power-shovel, which digs below the level of the top of the seam upon which it stands. In this way the workings were advanced until a workable amount of the upper seam was exposed in the face of overburden. At this stage a second set of similar excavators was installed to strip the overburden from below the lower seam and dig out the coal. Both seams were now developed simultaneously, with each stripping machine dumping the overburden on to the previously excavated ground. The relative digging capacity of each machine had been calculated to ensure that the removal of the bared coal kept pace with the stripping of the overburden. It was also arranged that each stripping machine discharged the excavated overburden against the exposed fault-face on the west side of the pit at the beginning of each cut. In this way room was left between *D* and *H* (Map C) for exit roadways formed of bared coal along which the excavated coal could be hauled by lorries to ground level from the pit.

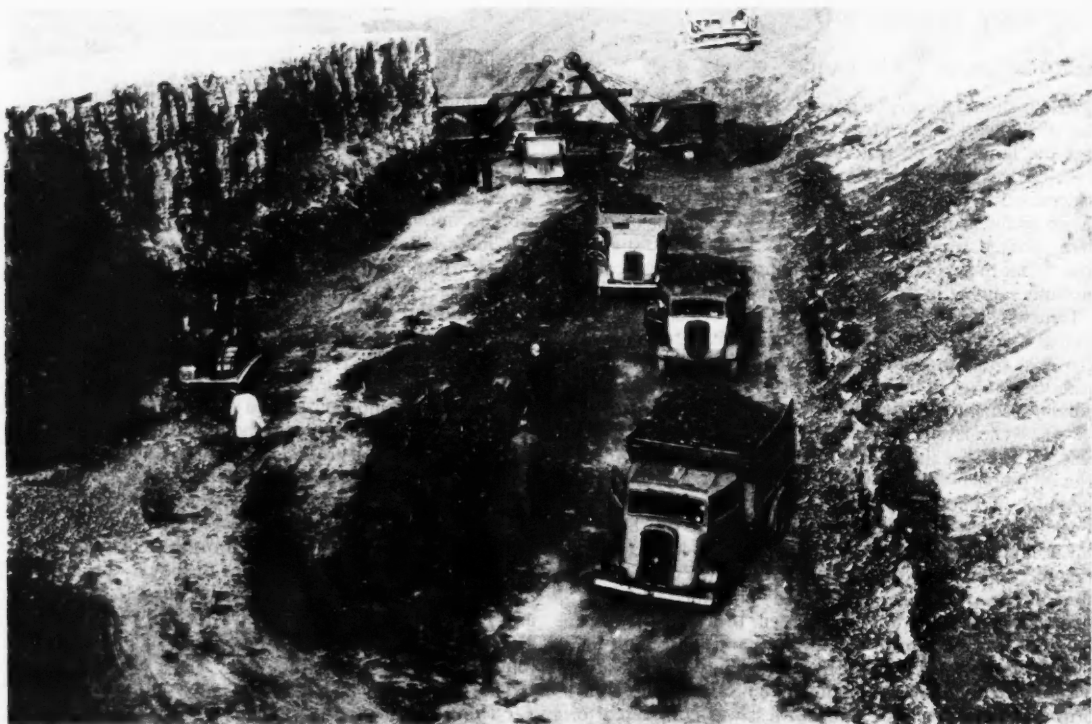
The pit was excavated in this way until the position *E-F* (Map C), marked by the 40-foot isopachyte line, was reached. The workings between these two points were filled, levelled and re-soiled with the material previously deposited; but the part of the face beyond *F* to the north-east was advanced farther down dip to its final stage between *G* and *H*. The exit roadways formed of bare coal between *D* and *H* were then removed, but the gullet was allowed to remain open to act as a reservoir for the water which would drain into it from the next series of excavations on the up-throw side of the fault.

The eastern half of the site was excavated in the same way as the western, starting with an initial gullet between *I* and *J*. The overburden from the first series of excavations was heaped in reception areas between *ST* and *NT*. Sufficient soil was also dumped behind these heaps to be used for re-soiling the filled in parts of the final workings. As the working face advanced (as illustrated in Map C) from *IJ* through *KL* and *MN* to *OP* the open gullet left between *D* and *H* in the previous part of the operation was steadily filled in. This enabled room to be left on the east side of the workings for exit roadways on the bared surface of the coal seams to be maintained between *N* and *T*. When the position *OP* was reached the pit became progressively narrower, as it was limited by the 40-foot isopachyte line between *O* and *S* (see Map C). The overburden was consistently dumped against the unworked face of overburden along this line until the final position of the workings



Geological, Contour, & Isopachyte Maps of an Opencast Coal Site





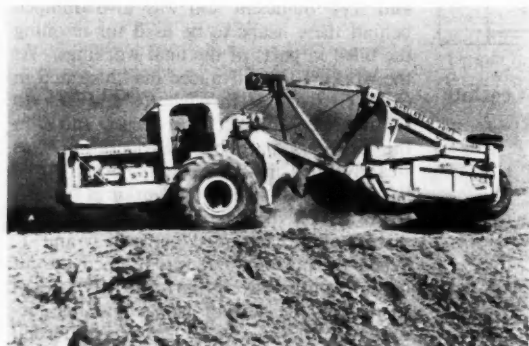
Cross-section of an opencast coal site. The 5-ton lorries indicate the scale of the operations.

between *S* and *T* was reached. The coal still left in the roadways between *N* and *T* was then removed, and the final gullets filled and resoiled by using the material previously deposited nearby for this purpose.

Throughout the whole of the opencast operation, the dumped overburden was levelled and resoiled by tractor-drawn scrapers and bulldozers. These scrapers had also been employed to strip off the soil ahead of the working face of the pit, to be used for resoiling the levelled overburden dumped in the worked-out area. In this way, the land was completely levelled and resoiled within a few weeks after all the available coal had been removed. The

land was then seeded with grass and returned to the farmer. When settlement was considered more or less complete, new drains were made, and the ground fully restored to agriculture.

Unfortunately, few sites remain where coal can be worked successfully by opencast methods, but at many places in our coalfields the experience gained in opencast mining during the war may profitably be applied to areas wherein, not only the coal, but also the associated clays could be excavated as valuable resources of material for making fire-bricks and the builder's brick now so urgently required.



A 'scraper' being used to bare the coal seam after topsoil and overburden has been removed.



A bulldozer pushing down a heap of dumped material in an opencast coal mine.

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This is the second of two articles by Dr. Mendelssohn dealing with developments in low-temperature physics. In the first article, published in the November issue (Vol. VII, pp. 341-347), Dr. Mendelssohn took the story as far as the liquefaction of helium. He deals here with researches in which temperatures closer to absolute zero than the temperature at which helium liquefies have been reached, and discusses some of the remarkable properties of liquid helium.

Approach to Absolute Zero

K. MENDELSSOHN, M.A., Ph.D., F.Inst.P.

WITH the liquefaction of helium, the last of the so-called 'permanent' gases, no further progress in the approach towards absolute zero seemed possible. Drawing off the vapour above liquid helium will result in cooling it to about 0.75°K and thus there remains no more than a fraction of a degree between this temperature and absolute zero. To the physicists of the nineteenth century, who in their experiments reduced the absolute temperature by successive steps of tens of degrees (or even a hundred), this last three-quarters of a degree would indeed have seemed insignificant. Today we know that absolute zero, the ultimate goal of their endeavours, can never be reached.

The small gap of 0.75° which seems to separate the helium region from absolute zero is in reality an illusion produced by our peculiar choice of a temperature scale. This scale is most satisfactory when applied to temperatures met with in everyday life, and for ordinary purposes the notion that steps of, say, one degree each correspond to equal changes in temperature is quite correct. However, one has to be careful when applying this to very low temperatures. Cooling by one degree from 27°C – 26°C (300°K – 299°K) reduces the absolute temperature only by one three-hundredth but cooling from 2°K – 1°K reduces it by one half of its value. It is therefore well to remember that a cooling from 1°K – 0.1°K represents a reduction in absolute temperature by a factor of 10, a reduction equivalent to a cooling from room temperature (about 300°K) to the critical point of hydrogen (30°K).

It is therefore clear that a cooling method which, starting from the range of liquid helium, would approach absolute zero to within a tenth of a degree or less would open up to research a relatively enormous new range of temperatures. With no further gases to liquefy, the question arose by what other means could a cooling be produced.

More than a century ago scientists began to realise that the true nature of heat is the irregular motion of the constituent particles of matter. In a lump of metal the atoms are arranged in a neat regular pattern which we call a crystal lattice. When the metal is heated the atoms vibrate more and more violently about the positions in which they are held by mutual attraction. When more heat is supplied the stage will at last be reached when they break away from these positions; at this stage the substance melts. Further heating imparts so much energy to the atoms that they push completely away from their neighbours, and thus the liquid evaporates and becomes a gas. A rise of temperature therefore means an increasing degree of disorder in the arrangement of the atoms. The degree of disorder, which is called the entropy of the substance, is therefore a most important quantity when

temperature changes are to be considered. In order to decrease the temperature of a substance, we must be able to reduce its entropy. The close connexion between gas liquefaction and the production of low temperatures is due to the fact that the entropy of a gas varies with pressure and that, owing to the high compressibility of gases, considerable entropy changes can be produced by the application of moderate pressures. The same number of gas molecules compressed to a small volume represents a state of greater order than when they are spread over a large volume. In the process of compression, as the entropy is reduced, heat is liberated, and this heat, abstracted from the gas, is carried away by the cooling water of the compressor. If now the process is reversed, i.e. if the gas expands but without regaining the lost heat, the loss in entropy will make itself felt as a drop in temperature.

To discover a means by which the temperature of a body can be reduced below the helium range therefore meant finding a physical system whose entropy, can be changed by some means like that of a gas by compression. The search for a suitable system is made more difficult by the third law of thermodynamics which (as mentioned in the first article) postulates that at absolute zero all substances have zero entropy. In fact at 1°K the total entropy of most physical systems is already so small that no useful entropy changes are possible.

The solution to the problem was suggested in 1926 independently by Giauque and Debye who proposed to make use of the magnetic properties of matter. In the atoms constituting a solid body there exist elementary magnets and they, too, are capable of exhibiting various degrees of order. At high temperatures they point at random in all directions while at low temperatures their direction will be parallel. The temperature at which the decrease in entropy due to this orientation will take place depends on the forces acting between the magnets in question. The phenomenon of magnetism is caused by the movement of an electric charge. The magnetism of an atom may be due to the rotation of an electron in its orbit or around its own axis; its 'spin' as it is called. In most substances these little elementary magnets are 'saturated' by others pointing in the opposite direction and they are thus in a state of order. However, it was known from measurements carried out in Leyden that the magnets due to unsaturated electron spins in some paramagnetic* salts (the classical example is gadolinium

* When a substance is placed in a magnetic field it may either draw in the lines of force (*paramagnetism*) or push them out (*diamagnetism*). In both cases no magnetism will be left when the magnetising field is removed. If the substance, however, remains magnetised it is called *ferro-magnetic*.

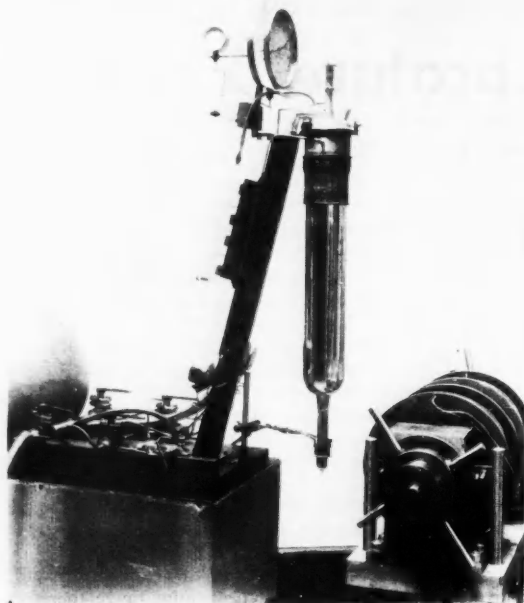


FIG. 1.—Apparatus for magnetic cooling in operation. The lower end of the cryostat is narrow so as to allow its insertion between the pole pieces of a strong electromagnet. The small coil surrounding the narrow part serves to measure the magnetic susceptibility of the salt and thereby to determine its temperature.

sulphate) remain still unorientated at helium temperatures. The cooling method proposed by Giauque and Debye consists in first aligning the elementary magnets at the lowest temperature attainable with liquid helium by means of an external magnetic field and then to demagnetise the substance adiabatically, i.e. without gain of heat. The external field thus forces the elementary magnets into a high degree of order and this reduction of entropy, just as in the compression of a gas, results in the development of heat. In the gas the heat of compression is removed by the cooling water; the heat of magnetisation in the paramagnetic salt is carried away by the liquid helium. The next step is to insulate the salt thermally and now the stage is set for the actual cooling process, the demagnetisation. The removal of the external field, like the release of the pressure in a compressed gas, then produces a decrease in temperature.

Seven years after it was proposed the practicability of the magnetic cooling method was demonstrated experimentally in Berkeley, Leyden and Oxford. (Figs. 1-2.) The difficulties which had to be mastered were considerable. Heat influx has to be reduced to an extremely low level while on the other hand heat must be exchanged between the cooling agent (the paramagnetic salt) and the specimens to be cooled. Here one is faced with an entirely new problem. At all higher temperatures a gas is usually employed to act as the heat-exchanging medium. Below 0.5°K the

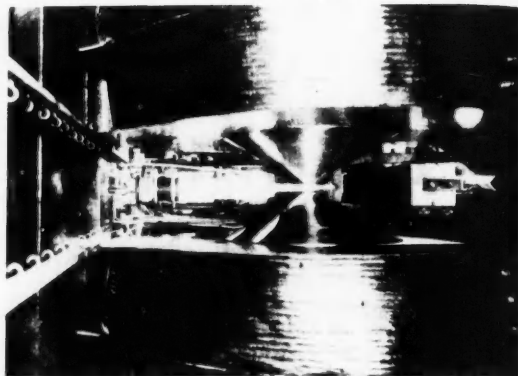


FIG. 2.—A cryostat, similar to that shown in Fig. 1, between the pole pieces of the large electromagnet at Paris.

only fluid suitable for heat transfer is liquid helium but owing to its peculiarities it cannot be used in open vessels. However, K rti and Simon in Oxford have developed an ingenious technique, employing sealed capsules which contain the paramagnetic salt and helium gas at high pressure. At low temperatures, the helium inside the capsule condenses and provides sufficient liquid to ensure heat exchange. In this way it has been possible to investigate the properties of the salt, of liquid helium, and of an added third substance down to temperatures of a few hundredths of a degree absolute. Working together with P. Lain  at the great electro-magnet in Paris (Fig. 2), these authors discovered that one of the cooling substances (an iron alum) at exceedingly low temperatures became ferromagnetic, showing magnetic properties like iron or nickel. In these experiments, for which a complete helium liquefier was taken from Oxford to Paris, the cryostat plus all subsidiary apparatus had to be moved on rails in and out of the magnet which is immobile owing to its enormous weight.

Future Prospects

The departure from gas liquefaction and the success of the magnetic method have naturally led to the question whether other cooling methods could be devised which permit a descent to even lower temperatures. What is required, of course, are physical systems remaining in a state of disorder even at temperatures accessible with the magnetic method. Ferro-magnetism, i.e. a spontaneous orientation of the spins, in the case of alum is an indication that the usefulness of paramagnetic salts will be exhausted at temperatures much below 0.1°K . However, atoms harbour elementary magnets which interact with each other even more weakly than those due to electron spin: these are the spins of the nuclei. K rti and Simon, as well as Gorter, have suggested that these nuclear spins are likely to form a cooling agent which may lower the temperature limit to less than a ten thousandth of a degree.

Besides the usual problems of cryogenic technique in an accentuated form, new and fundamental difficulties may arise in these new temperature domains. Normally the notion of temperature is connected with the kinetic energy

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the success of the question which is involved which is. What is the main thing in a substance with the spontaneous indication of the exhausted energy. However, atoms with each other and electron spin; mon, as well as ions are likely to be in a temperature

unique in an apparatus. The difficulties may be normally the magnetic energy

of the atoms and it is this energy which is directly altered in the adiabatic expansion of a gas. The magnetic field, on the other hand, interacts with spins inside the atoms and the substance as a whole will not take up the low temperature of demagnetisation until thermodynamic equilibrium between the elementary magnets and the kinetic energy of the atoms is established. So far, unfortunately, theory cannot provide much help in predicting whether or not this equilibrium will be established within a reasonable time. Theoretical estimates, which in paramagnetic salts had indicated that the interaction between spins and the atoms forming the crystal should be very slow, have fortunately been shown by experiment to be erroneous. A valuable medium for energy exchange at very low temperatures is provided by the free electrons which are responsible for the good electric conduction of metals. These electrons move through the metal like a gas and theory indicates that even very small energy differences within the substance will be equalised in a short time. In this connexion a cooling method proposed by the author some twelve years ago may turn out to be useful. This is the adiabatic magnetisation of a superconductor (see below), a process which preliminary experiments have shown to be feasible. Since in this case the working substance is a metal, thermodynamic equilibrium within the cooling agent and with a second metal should be simpler than in insulators because of the presence of free electrons. This cooling method and others based on the properties of liquid helium are, however, in a number of respects inferior to demagnetisation of paramagnetic salts and are unlikely to compete with it in ordinary single-stage cooling.

One of the main problems in the range of extremely low temperatures is their measurement. Gas and vapour pressure thermometers have lost their usefulness below the helium range. A useful secondary thermometer is provided by the change in the magnetic behaviour of the cooling salt with temperature. However, this begins to show appreciable deviations from the theoretical formula when interactions between spins comes into play, i.e. with decreasing temperature. A thermodynamic scale of temperatures can be obtained by very accurate calorimetric measurements. This has actually been done in the magnetic range by Giauque and by Kürti and Simon. The latter authors have overcome the experimental difficulty of supplying heat homogeneously to the salt by the neat trick of heating it with gamma-rays.

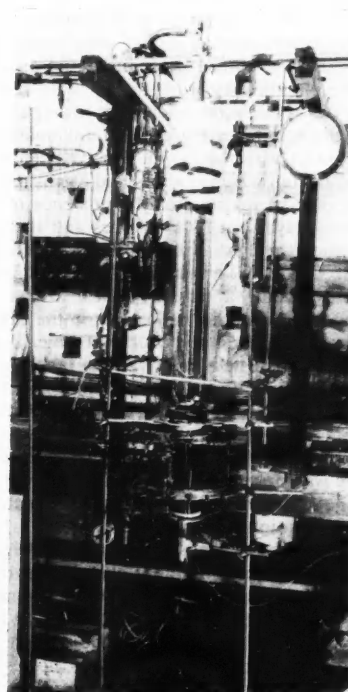
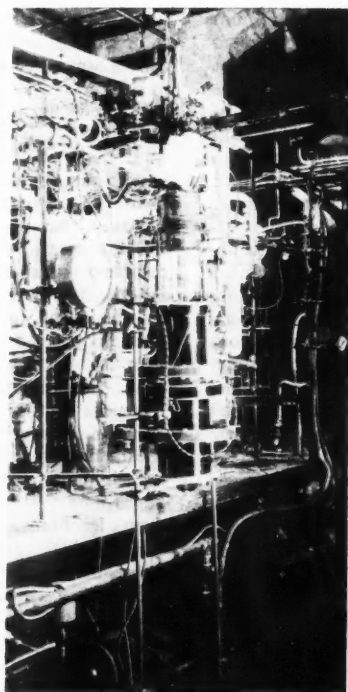
As a physical phenomenon, a cooled paramagnetic salt is unique in itself. The temperature of interstellar space is estimated to be somewhat above 1 K and it is a

strange thought that a small capsule inside a physical apparatus may be the coldest place in the whole of the universe! However, one need not descend below the helium range in order to encounter effects which are quite outside the range of normal physical phenomena.

The very day on which helium was liquefied, Kamerlingh Onnes tried to solidify it by the usual method, i.e. by reducing the vapour pressure. The attempt proved unsuccessful and we know now that helium remains a liquid down to absolute zero. Solid helium can indeed be obtained but only by exerting external pressure. This strange anomaly is coupled with the peculiar low density of the liquid. Even more disturbing was the discovery, also by Onnes, that at 2.19° K the density of the liquid has a sharp maximum. In the following years Keesom and his co-workers in Leyden systematically investigated many properties of the liquid and they came to the conclusion that the liquid can exist in two different modifications—helium I which is stable above 2.19° K, and helium II below this temperature. At 2.19° K there exists a rise in the specific heat which has been called the lambda-point. The two liquids never exist together and there is no latent heat connected with the transformation.

Superfluidity

While helium I is a fairly normal liquid, helium II is an extremely peculiar substance and the last years before the war brought a veritable avalanche of most astonishing observations. It was discovered simultaneously in Leyden



Figs. 3 and 4.—Small-scale cryostats with solenoids for experiments on superconductors.

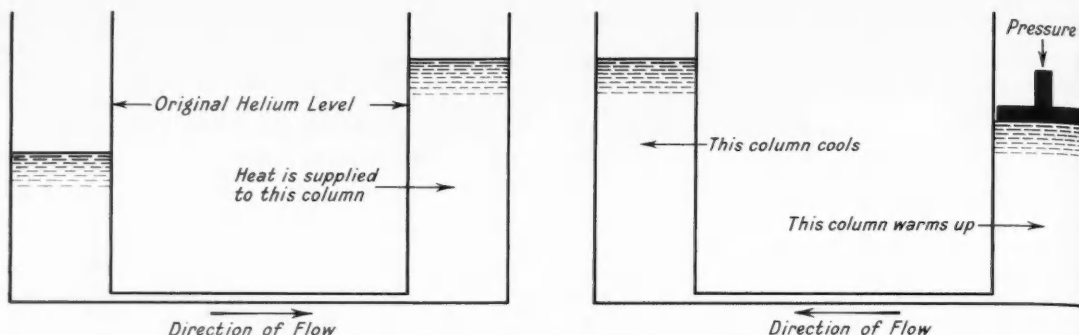


FIG. 5 (Left.—The thermo-mechanical and (right) the mechano-caloric effect in liquid helium II. Two volumes of liquid helium are connected by a fine capillary. When heat is supplied to one of these a flow of helium takes place in the direction towards the higher temperature. When helium is forced through the capillary a cooling is observed at the exit and a heating at the entrance

and Oxford that the liquid has an extremely high heat conductivity, exceeding that of copper or any other conductor. Another discovery, made simultaneously in Moscow and Cambridge, showed that the viscosity measured in flow through capillaries is almost infinitely small. On the other hand, viscosity measurements with a rotating disc yielded quite reasonable values. Allen and his co-workers in Cambridge, investigating more closely the heat conduction process, found that when heat is supplied to one end of a tube containing helium II a flow of liquid takes place in the direction of the higher temperature (Fig. 5). For high heat inputs this flow can be so strong that the liquid spurts from the open tube in a fountain several inches high. The reverse effect was observed by J. G. Daunt and the author, who forced liquid helium through a capillary plug and observed that the ejected liquid was cooled while the liquid on the pressure side of the plug became warmer.

As though this were not enough, a peculiar flow of helium II takes place along any solid surface which is in contact with the liquid. The vehicle of this flow is a film of helium which is about 100 atoms thick. Little is known about the reasons for the existence of this comparatively thick layer but its properties and the flow phenomena to which they give rise have been investigated systematically at Oxford. This surface transport has been recognised only recently and it may appear strange that such a striking effect was not noticed earlier in the many hundred experiments which in the course of time have been carried out with liquid helium in various laboratories. True enough there were one or two indications of this curious phenomenon. However, the real reason is that owing to the small amount of heat required to evaporate the film, its effects were usually swamped by the heat influx into the cryostats. It was only in work with the small-scale cryogenic technique that suitable conditions were created for consistent observations of the film transport.

The observations are striking in their simplicity. (Fig. 7.) For instance, an empty glass beaker dipped half-way into the liquid will be filled by surface transport over the glass wall until the level inside equals the height of the liquid outside. When raised up, the beaker will empty itself by the same process. This flow is, however, unlike that in an ordinary siphon since the rate of flow is unaffected by the level difference and by the height of the intervening glass wall. The inescapable conclusion is that the film transport

must be free of friction and that instead of obeying the rules of ordinary liquid flow, its character is determined by the laws of quantum mechanics. A beaker full of helium II lifted completely out of the liquid presents a remarkable sight. Watching it closely one can see drops of liquid collecting on the outside which fall back into the helium bath. There is a strange fascination in seeing before one's own eyes the world of classical physics replaced by that of quanta.

Superconductivity

The odd behaviour of liquid helium was, however, not the only surprise which the temperature region below 10 K. had in store. One of the most interesting questions to be investigated in the approach to absolute zero is the conduction of electricity through metals. For a pure metal, the resistance decreases rapidly as the temperature is lowered and, in a specimen of perfect purity, it would seem to vanish at absolute zero. On the other hand, recent measurements on gold seem to indicate that at very low temperatures the resistance begins to rise again. This rise in the resistance of gold is quite unexpected, but an even more unexpected result was obtained by Kamerlingh Onnes in 1911. Determining the resistance of mercury at helium temperatures, he found a sudden drop to immeasurably small values at 4 K. Subsequent experiments showed that at this temperature the electrical conductivity indeed becomes infinite. This phenomenon of 'superconductivity' as it is called has since been

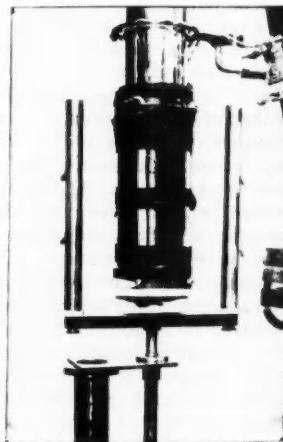


FIG. 6.—Rotating radioactive source used for calorimetric experiments at very low temperatures. The paramagnetic salt is inside the cryostat occupying the centre of the device.

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observed in a number of metals, all belonging to certain groups of the periodic table. The temperatures at which the resistance disappears vary from 0.3°K – 10°K and it may be that at sufficiently low temperatures all metals become superconductive. The general impression is, however, that this will not be so.

Superconductivity has permitted a number of very spectacular experiments. A current which has been induced in a ring of superconductive wire, for instance, will keep on running until the wire is warmed up. On June 3, 1932, such a 'persistent' current was set running in Leyden and then flown in a helium cryostat to London where its existence was demonstrated at the Royal Institution. Another striking feature of a super-conductor is its complete diamagnetism, i.e. the magnetic induction inside a superconductive metal is always zero.* Because of this diamagnetic behaviour, superconductivity has sometimes been described as a purely magnetic phenomenon and it has been suggested that its occurrence may be due to the action of electron spins. However, a few years ago, Kikoin and Gobar, two Russian scientists, demonstrated by direct experiment that this diamagnetism is caused by electronic currents.

However, although its electrical resistance is zero, it is not possible to pass through a superconductive wire a current of unlimited strength. Superconductivity breaks down and ordinary resistivity reappears when a certain critical current is exceeded. The strength of this current depends on temperature; it is zero at the 'transition point', i.e. at that temperature at which superconductivity is first noticed when cooling the metal. Near absolute zero the critical current becomes independent of temperature but for the same diameter of conductor it is different for different metals.

It is only natural that to many inventors the phenomenon of zero electrical resistance should have suggested the construction of magnetic and electrical contrivances such as electromagnets which do not waste any energy as heat. It must, however, be remembered that up till now the production of large quantities of liquid helium has been prohibitively expensive and would hardly justify the saving of energy that would result from a resistance-free current. Moreover, most of these attractive schemes involve a high concentration of magnetic energy and ignore the fact that there is a limit to the magnitude of the super currents, which does not permit the production of fields higher than one or two thousand gauss. Nevertheless the war has brought the first practical application of superconductivity in the form of a specially sensitive bolometer which has been developed by D. H. Andrews and his associates

* It is, of course to be expected that a perfectly conducting body which is brought into a magnetic field will not be penetrated by lines of force because compensating currents are induced on its surface. However, even a body which is cooled to superconductivity in a constant magnetic field will expel the magnetic flux and compensating currents are set up.

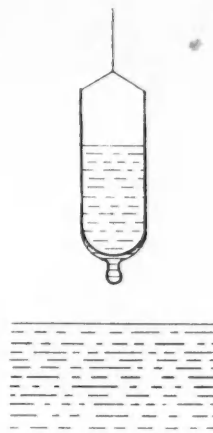
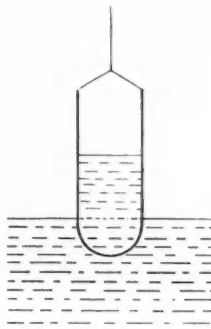
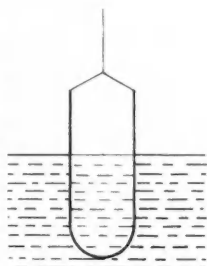


FIG. 7.—Film transport in liquid helium II.

in America. (Fig. 8.) The instrument makes use of the rapid change of resistance with temperature in a wire when becoming superconductive. Thus a very slight change in the temperature of the wire, such as is produced by weak radiation impinging on it, can be recorded as a considerable variation in electrical resistance. By attaching the bolometer to a scanning device such as is employed in television, pictures can be taken in the very far infra-red.

Although innumerable attempts have been made to provide a theoretical interpretation of superconductivity, they have all met with failure. Adequate thermodynamical and electro-dynamical descriptions of the phenomenon have indeed been given but they have brought us little nearer to an understanding of the physical processes involved.

Quantum Phenomena

There seems to exist a peculiar similarity between superconductivity and the strange transport effects in liquid helium. At first sight, one may be reluctant to compare the behaviour of electrons in a metal with that of atoms in a non-conducting liquid but certain features of this analogy are too striking to be overlooked. In both cases a transport of matter without friction is taking place and in both cases this frictionless transport breaks down when a critical rate of flow is exceeded. Another common feature is the remarkable degree of disorder in space persisting to temperatures near absolute zero. Helium and the free electrons in a metal which may be looked upon as a gas are the only substances which at absolute zero have not taken up the orderly arrangement of a lattice structure; they do not crystallise. This is a most remarkable state of affairs since we have seen that the third law of thermodynamics postulates for all substances a state of complete order at absolute zero.

When determining the degree of order in a substance we fortunately need not rely on vague estimates based on its structure. All one has to do is to measure its specific heat down to the lowest possible temperature and these results

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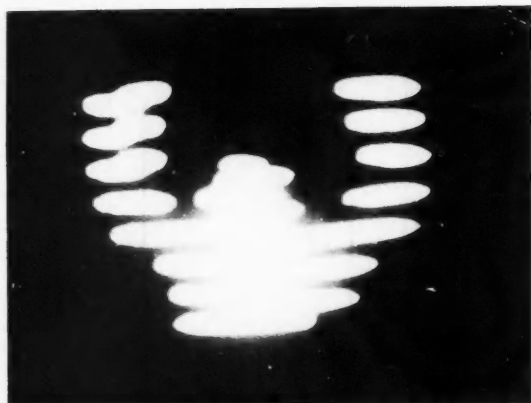


FIG. 8.—Photograph taken in the far infra-red with a superconductive bolometer. The picture represents Professor D. H. Andrews with his arms raised and it was produced by heat radiation from the surface of his clothes.

provide us with a direct measure of the entropy, i.e. of the degree of disorder existing in the substance. Such determinations have been carried out both for liquid helium and for superconductors and the result is somewhat perplexing. When liquid helium is cooled below the lambda point or when a metal is cooled to superconductivity, the entropy decreases rapidly. In other words, the appearance of frictionless transport is accompanied in both cases by a sudden increase in the state of order. Since, as we have just seen, there is no orderly arrangement in space, the question arises how this high degree of order, as indicated by the loss in entropy, is realised.

As so often happens in modern physics the dilemma seems to be caused by our accepted ideas concerning physical quantities. We are accustomed to regard as a high degree of order a state in which particles, atoms, or molecules, are arranged in a regular pattern as is indeed the case in a crystal. However, when fully describing a set of particles it is not sufficient to know their positions, we must also know their velocities. To know where a particle is at present is not enough, we must also know where it will be in the next instant. In fact, the velocity co-ordinates of a body are physical quantities which are as important as the familiar co-ordinates denoting its position. Our usual conception of order takes into account only the co-ordinates of position. A gas which condenses into a liquid and a liquid which crystallises into a solid are successive stages in this 'side by side' order. There is, however, no reason to believe that this is the only way in which a state of order can be achieved. A similar ordering process can for instance take place with regard to

the co-ordinates denoting velocities. Bound as our imagination is to the limit of three dimensions, we find it difficult to visualise such a 'condensation' according not to positions but to velocities, but that does not mean of course that such a state cannot exist.

It was one of the unsatisfactory features of Nernst's third law of thermodynamics when first formulated that it was not applicable to gases. It appeared impossible for a gas, in which the particles move at random, to achieve a state of complete order. As Planck pointed out at the time, the application of the quantum theory to the kinetic energy of an ideal gas seemed to be without physical reality. Since then, such a 'degenerate' gas has in fact been discovered. The free electrons in a lump of metal, while remaining disordered in ordinary space, present a more orderly aspect with regard to the velocity co-ordinates. It is possible that the strange phenomena of liquid helium and superconductivity represent the most extreme degree of this degeneracy; a 'condensation' into the lowest state of kinetic energy.

For a freely mobile particle this lowest state is not zero but has a small energy conferred upon it by the uncertainty principle. This principle states that the position and velocity of a particle cannot be determined with greater accuracy than to a certain limit which is set by Planck's quantum constant. When applying these considerations to liquid helium or to a superconductive metal, one arrives at a strange conclusion. Since it can be argued that it is impossible to determine the position of a helium atom or of an electron within more accurate limits than those set by the boundaries of the substance, the lowest state of kinetic energy should depend on the size of the specimen. That is to say, a helium atom in a small container should have a higher energy than one in a large container!

Whether this is actually the case, one does not know as yet. The whole problem is one on which opinions are much divided at present. However, there are some significant pointers as, for instance, the fact that the frictionless flow of helium is faster in tubes of *small* diameter than in wide ones. Nevertheless, many more experiments will have to be made before safe conclusions can be drawn as to the mechanism of these peculiar phenomena. Judging by past experience, it is likely that future experiments in this field will have surprises in store and that our present ideas, vague as they are, may have to undergo radical changes. One thing, however, seems fairly certain. A beaker full of liquid helium or a lump of superconductive metal seems to be a structure which to some degree is removed from the realm of classical physics and the behaviour of which is determined by the laws of quantum mechanics as much as that of a single atom. Indeed it appears that here low-temperature research has presented us with the unique spectacle of a manifestation of the quantum principle on a macroscopic scale.

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Edison—Master Inventor

M. SCHOFIELD, M.A., B.Sc., F.R.I.C.

THAT amazing American man of science, Thomas Edison, born a century ago on February 11, has attracted more pens to the writing of his achievements than any other inventor. 'Amazing' is the appropriate term; for in the history of invention or of applied science one cannot readily find any other figure with the energy to work up to twenty hours a day, to be satisfied with an hour or so of sleep, and to take out over a thousand patents as fruits of his endeavour. To Edison the inventive urge was a cult, a religion. He had nothing else to sustain him: no love of books, of the arts or of music, no inspiration or literary background to rouse him to record on the world's first phonograph any other message than "Mary had a little lamb". But what vitality had this man to whom genius was "one per cent inspiration, ninety-nine per cent perspiration"! And there was his saving grace of humour to make up for any shortcomings in the arts, a humour sustaining perpetual youth in a man who, when asked the secret of his uncanny powers of endurance, solemnly attributed it to the Welsh rarebit he had every morning for breakfast.

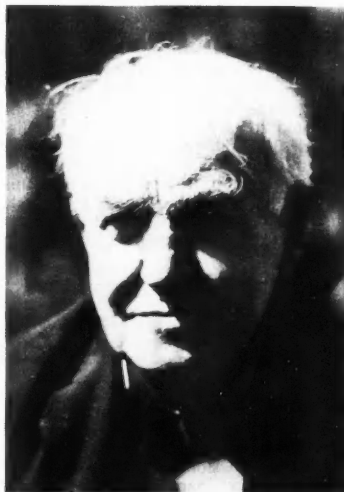
To what extent was Edison a scientist, or even that "new combination of scientist and man of extraordinary common sense" which Henry Ford claimed him to be? That question is the more readily answered if one limits the term 'scientist' to one with a sound basis of knowledge of his particular subject, coupled with the ability to build on that basis. All credit to Edison that, with no academic training in science and hardly any schooling, he acquired what fundamentals he could from books. Edison certainly chose the right books. He read Fresenius when first dabbling in chemistry, and frequently consulted Watts' Dictionary of Chemistry when more deeply involved. As for his fuller delvings into electrical science, he himself saluted Faraday as the 'Master Experimenter' and told how much he learned from this real genius who inspired so many.

Making allowances for the extent of scientific progress in his early days, Edison's knowledge was patchy indeed. Edison was a good guesser and a great improviser. We should rather call him a scientific inventor, an inventor who showed real evidence of scientific method at times in his carrying out of many experiments to eliminate negative factors; and one who could use his powers of observation to interpret results, and then go on to discover the Edison Effect which in turn inspired Fleming to give us the radio valve.

Edison as a boy had shown his initiative when he persuaded a railway-company to let him dabble in chemistry in a little-used smoking-car. That 'smoking-car' became such in a double sense when phosphorus proved a fire-raiser, and young Edison and his bottles were thrown off the train by an irate railway-guard.

But Edison's motto might well have been "Let nothing you dismay". He passed on to another phase, just as in later years he could pass on to success after bitter disappointment and much hard striving in experiments leading to a dead end. Edison was ever an optimist: "I was never myself discouraged. . . . I cannot say the same of my associates" was his comment after that supreme effort with the carbon-filament electric lamp. The train incident and his strong interests in electrical subjects did not lead him to desert chemistry.

When he came to search for the ideal lamp filament he studied the rare metals, together with titanium, zirconium and barium, coating fine hair-like wires with an oxide preparation, and then trying



Thomas A. Edison (1847-1931).

boron and chromium refractories set between conducting points. When he invented the Edison alkaline storage battery he himself prepared nickel and iron oxide of high purity in a laboratory full of test cells and tumblers. And when in the 1914-18 period the United States ran short of phenol and cresol imports from Europe, Edison brushed aside his technologists who said it would take six months to design and build a manufacturing plant; he set forty chemists and draughtsmen to work the clock round in eight-hour shifts, and completed the plans within a week. His Silver Lake plant came into operation in another seventeen days. And he did all this because he required cresol for production of his phonograph records.

The harvest from Edison's years of intense endeavour, from his "new school of applied science" as it has been called, proved his powers as a practical man,

while in its variety it supports Henry Ford's dictum that "Mr. Edison cannot be classified". Rough methods of telegraphy then in use roused Edison in his early period to conjure forth the automatic repeater, the quadruplex and printing telegraph, and the sextuplex transmitting idea, all of which were purchased by the Western Union from their young employee. In 1875 he perfected the telephone invented and patented by Bell, but he sold the latter his improvements in face of patent rights. Then the phonograph, hand-driven at first and with a cylinder covered with tinfoil; the kinetoscope, forerunner of the cinema projector, together with a camera for photographing with continuous film and the well-known perforated film which has remained a standard for fifty years; the Edison alkaline accumulator; the dictaphone; the mimeograph; the wireless aerial sold to the Marconi Company; the magnetic iron-ore separator, successful until an age of prodigality came with the discovery of rich ores from the Missabe Range; the power-supply systems he invented—one could go on and on listing the many products of his fertile imagination.

His discovery of the most suitable carbon filament for the electric lamp—a master invention of which more later—proved but an opening to a wider field of applied science which he was to explore. He led his team on to study the blowing of glass bulbs in large numbers, vacuum-holding leads, wiring systems, fuses and electrolytic type meters. As Faraday had laid foundations of electrical science, so did Edison apply them by founding the electric lighting system; by introducing independently of Hopkinson the three-wire system to save copper; by designing new types of dynamos for constant voltage but varying loads; and by foreseeing the need for central power stations. He realised the necessity for large dynamos of low resistance, and he insulated his armatures and commutators with mica. His use of direct current was to be expected, for he realised that a demand would arise for current in running electric motors and for charging accumulators (A.C. had not yet been adapted for such purposes).

Yet to appreciate Edison's all-consuming urge to create, to invent and fill a need, one selects his lamp filament as a classic of all time. Joseph Swan, it is true, had first worked on a carbon resistor or rod within a bulb and returned to the problem in 1877. Three years later he took out a patent for the evacuation of his lamp which involved an essential for all lamps: the exhaustion while the lamp was glowing, so as to remove occluded gases. It was this patent which led Edison to combine with the Swan interests; yet he himself had hit on the idea while experimenting with filaments other than carbon. But Swan did not give us the practical lamp for everyday use that Edison's

large-scale effort gave us. He foresaw all the essentials for a lamp: a small current at high voltage, the necessity for 'subdividing' the current hitherto consumed by the impracticable arc-lamp, and using this divided current in a number of small lamps which could be switched on and off at will and would not require a warming-up period, as did the Nerst lamp. So this restless man, who considered 1½ hours sleep a night sufficient, drove his team at Menlo Park.

He tried carbonised paper and tissue coated with tar and lampblack; then iridium and platinum again; then his search for a tenacious filament took him back to carbon and prompted his attempts to conjure one from sewing thread in U-loops and carbonised in a nickel mould. Most of such filaments broke *en route* to the glass-blowing shop, but one survived to burn for over forty hours: "We turned on the current. It lit up, and in the first few breathless minutes we measured its resistance, and found it was 275 ohms—all we wanted. Then we sat down and looked at the lamp. We wanted to see how long it would burn. The problem was solved—if the filament would last. The day was—let me see—October 21, 1879. We sat and looked, and the lamp continued to burn, and the longer it burned the more fascinated we were. None of us could go to bed, and there was no sleep for any of us for forty hours."

Then the next phase, the great drive for a more durable filament. He set out to carbonise every conceivable carbonaceous material: tarred paper, flax, celluloid,

wood cellulose from many sources, nut shells, coconut hair, and even some hairs from the beard of his associate, Mackenzie. Grasses and canes brought him nearer; and then one day he seized a strip of bamboo from the palm-leaf fan in his room, carbonised it, and found it superior. So the search spread across continents as workers with portable carbonising apparatus were sent to Brazil, Jamaica, Uruguay, Argentina, Ceylon, India, Malaya and Japan. Since Japanese bamboo proved superior, a farmer in that country was enlisted to cultivate the right type.

And Edison rounded off his great theme not only with the 'squirreled filament' from cellulose, and with 'hard metallised' filaments from high-temperature carbon, but with the forecasting of the coiled-coil lamp and of the ideal lamp giving 'light without heat', and with the discovery of the Edison Effect which came when he placed a small metal plate between the straight parts of his carbon filament and put a galvanometer between the positive and the plate terminal. A small current was noted, yet no current passed when the negative leg of the filament was connected to the plate—hence the lamp behaved as a valve. Edison did not pursue this matter further, but patented it as he did most of his discoveries. So it was left to Fleming, scientific consultant to the Edison concerns in London, to be stimulated by this offshoot of Edison's inventiveness; while just fifty years ago, with the discovery of the electron, the cause became known

and the Edison Effect was realised to be due to the stream of electrons from the hot filament. Fleming's idea of a radio valve was furthered when the grid was added by Lee de Forest. But while including Edison among early workers in the radio field one must not forget his 1885 patent for the use of electrostatic induction in wireless telegraphy. His two high masts, erected far apart, supported metal surfaces, the transmitting one being connected to a loud telephone near the base and transmission being effected by discharging an induction coil into the metal surface on top of the mast. Electro-magnetic waves came to supersede electrostatic discharges; but Edison's aerial system was an essential which the Marconi Company successfully bid for in 1903.

Edison had a long span, showed frugal habits like those of 'G.B.S.' (at one time on the London staff of the Edison companies), but he had his black cigars and black coffee to stimulate him. He was ever the exceptional man; the man who did just what the doctor did not order. Yet at 70 his maxim was "work, and bring out the secrets of Nature and apply them". Above all was his amazing vitality, a *joie de vivre* which carried his associates with him. He was an optimist who could be relied upon to meet disappointment with the *bon mot*. Typical of Edison was the remark to his companion when he avoided his legal adviser on Broadway: "I was afraid to shake hands with him again until I found whether I could afford to pay his fee for it!"

Far and Near

Less Secrecy about Atomic Apparatus

As foreshadowed by Mr. John Wilmot, the Minister of Supply, during the debate in Parliament on the Atomic Energy Act, 1946, an Order has now been made under Section 11 (3) of the Act freeing certain classes of plant from the secrecy provisions.

The Order (S.R.O. No. 100, 1947) puts into effect the Minister's expressed intention of freeing the "ordinary laboratory tools of the nuclear physicist which have no defence significance" from the restrictions on the publication of information regarding atomic energy plant. No longer proscribed are the following classes of instruments:

Instruments for determining the existence or nature of any nuclear reaction other than a reaction involving the fission of atoms of atomic number greater than 89 and resulting in a total energy output from the plant in which the reaction takes place in excess of the total energy input; instruments for detecting, or measuring the properties of, charged or uncharged particles; cyclotrons, betatrons, synchrotrons, electrostatic generators, or other ion accelerators; and apparatus for generating charged or uncharged particles by the action on matter of accelerated

charged particles or of uncharged particles. Not exempt is apparatus for generating neutrons by a reaction involving the fission of atoms of atomic number greater than 89 and resulting in a total energy output from the plant in which the reaction takes place in excess of the total energy input.

Pan-African Congress

A PAN-AFRICAN Congress on prehistory was held last month. Some sixty delegates representing nearly thirty countries attended. A visit was paid to Ologasailie, the site in the Rift Valley near Nairobi where many human and animal remains and Stone Age implements have been found, and here Dr. L. S. B. Leakey explained his finds to the delegates. We hope to publish further details in our next issue.

Streptomycin: Health Ministry's Warning

OF recent weeks numerous individual appeals (including even broadcast S.O.S.'s over the radio) have been made for supplies of streptomycin for the treatment of dangerously ill patients. In view of these appeals, and because the clinical trials the Medical Research Council is organising are not yet completed, the Ministry

of Health issued on January 22 a strong warning that streptomycin is potentially dangerous and may cause serious ill effects in the patient, including permanent giddiness and deafness. For instance, in the very small number of patients with tuberculous meningitis whose life has been prolonged by the treatment, there has nearly always been permanent and serious mental derangement, blindness, or deafness.

Steps are, however, being taken to accelerate production in this country so that supplies may be available if the clinical trials prove favourable.

History of Science Society

A BRITISH Society for the History of Science has been formed and a provisional committee is at present engaged in working out its constitution. Anyone interested should get in touch with Mr. F. H. C. Butler, Ravensmead, Keston, Kent.

Obituary

THE death occurred on January 9 of Professor Karl Mannheim, Professor of Education in the University of London Institute of Education. Professor Karl Mannheim, who was born in Hungary,

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Dr. D. C. Martin, the Royal Society's new assistant secretary. He was formerly general secretary of the Chemical Society.

came to England after he had been removed from the Chair of Sociology at Frankfurt University in 1933, and took up an appointment as lecturer in sociology at the London School of Economics. He became attached to the staff of the Institute of Education in 1941.

Synthetic Penicillin

THE announcement that American research workers have recently isolated a specimen of synthetic penicillin has led to reports that synthetic penicillin will very shortly be cheaply and plentifully available. Such reports are, however, based on a misunderstanding of the nature of the synthesis achieved. The work has been done by Dr. Vincent du Vigneaud and his research team at the Cornell University Medical School, New York, and is described in *Science* (1946, Vol. 104, pp. 431-3). They found that the product of reaction between two decomposition products of penicillin—*d*-penicillamine and 2-benzyl-4-methoxymethylene-5(4)-oxazolone—possessed slight antibacterial activity. Assay showed, however, that the yield of penicillin was less than 0.1 per cent. A similar result was recorded by Oxford workers in 1942; they demonstrated that the activity of the product was due to penicillin by inactivating it with the highly selective enzyme, penicillinase. In view of the very low yield, however, the reaction was not further investigated at Oxford.

Starting with this very impure reaction product, du Vigneaud and his colleagues obtained, by a laborious extraction process, about 8 milligrammes of crystalline synthetic penicillin G. The course of the reaction and purification was followed by replacing some of the ordinary sulphur atoms in the penicillamine by a radio-active sulphur isotope which could be

detected by Geiger counters. The work is of considerable theoretical interest and a fine example of skilful chemical research, but it is of no commercial importance because the starting materials themselves are difficult and costly to synthesise, the yield is tiny and the purification process very time-consuming. Difficult though it is, however, the method may be valuable for preparing, for experimental purposes, varieties of penicillin other than those known to be produced by the mould.

Science Masters' Annual Meeting

THE 44th annual meeting of the Science Masters' Association was held in the Chemistry Department of the Royal College of Science, South Kensington on January 1-3. A programme of lectures (including the presidential address by Lord Horder) and of visits to places of scientific interest was arranged for the members. In addition to exhibitions by publishers and manufacturers of laboratory equipment there were two displays put up by individual members. The first of these was an exhibition of pupils' note-books, teachers' lesson notes, original wall-charts and models; the second was a collection of apparatus constructed or adapted by members to demonstrate important points.

Notable among these exhibits were: a microscope whose lens consisted of a drop of water suspended in a $\frac{1}{8}$ -inch hole, an excellent mechanical demonstration of Lissajou's figures, a device making use of 'Dufaycolor' film as a diffraction grating for determining the wavelength of light, a home-made synchronous motor for showing the stroboscopic effect; and a demonstration of standing waves based upon a variable-speed electric motor, an eccentric cam and a long piece of curtain spiral.

One item attracted much attention. This consisted merely of two halves of a steel knitting needle each of which was wired to one terminal of a sensitive centre-zero galvanometer. An inch or so of ordinary soda-glass tubing was slipped over the end of one-half of the needle, the other half being brought up so that it touched the outside of the glass tube. Strong heat was then applied at this point. The galvanometer pointer slowly moved a few divisions away from zero. Then, when the flame was removed, the pointer kicked violently in the opposite direction (registering a maximum current of 1.5 milliampere) and returned again to zero as the glass cooled. Sometimes the 'kick' failed to occur and there was in any event no predicting the direction in which the pointer would first move. A similar demonstration consisted of a 230-volt A.C. circuit interrupted by a half-inch gap between two metal rods. When a short length of glass rod was laid across this gap, the circuit remained open, glass being a non-conductor. But when the glass was heated, sparking began to occur at the points of contact with the metal rods, and current commenced to flow as indicated by the lighting of a carbon-filament lamp. Once established, this current continued to flow even when the flame was removed. It could be switched



Sir Ben Lockspeiser, Chief Scientist to the Ministry of Supply. Details about this appointment were published in our last issue.

on and off momentarily but if the glass were allowed to get too cool it would not start again. The same effect can be obtained using direct current. The demonstrator of these phenomena, who discovered them by accident, could not account for the effect. Nor could anyone else at the meeting, but it provided an excellent subject for debate.

The next Annual Meeting will be held at Sheffield University. Professor Irvine Masson, F.R.S. has consented to be President for the coming year.

Bleached Flour and Canine Hysteria

IN the bleaching of flour for human consumption several chemical substances are commonly used. One of these is nitrogen trichloride, and the process of bleaching with this agent is known as the agene process. Experiments made by Sir Edward Mellanby and described in the *British Medical Journal* (December 14, 1946, p. 885) show that ageneised flour can cause hysteria in dogs. Earlier researches had implicated the protein fraction of flour as a possible cause of canine hysteria, and Mellanby made his tests with ageneised flour as it was known that nitrogen trichloride had an effect on the principal protein (gluten) in flour.

Typical of the results obtained in these experiments is the effect on one particular pair of dogs: the first dog had a balanced diet incorporating flour that had not been bleached, and in a period of twenty-four weeks this animal had no hysteria or fits; the other dog, whose diet resembled that of the other animal except that ageneised flour was substituted for unbleached flour, had thirty attacks in the same period. Then for the following twelve weeks the first dog received bleached flour instead of unbleached flour, and the change of diet was followed by twenty-four attacks of

hysteria. The second dog, now receiving unbleached flour, recovered and had no attacks in twelve weeks.

Mellanby urges the testing of agensised flour on volunteers to see whether bread made from it has any effect on human beings. The *British Medical Journal* comments that "it is clearly undesirable that food unfit for dogs should be eaten by the human subject without at least a full realisation of the dangers involved".

British Council's Science Office, China

DR. R. A. SILOW, until recently a scientific officer of the Agricultural Research Council at the Plant Breeding Institute at Cambridge, has been appointed Director of the British Council's Science Office in China in succession to Dr. Joseph Needham.

Night Sky in March

The Moon.—Full moon occurs on March 7d 03h 15m U.T. and new moon on March 22d 16h 34m. The following conjunctions take place:

4d 02h	Saturn in conjunction with the moon,	Saturn	4 S.
12d 15h	Jupiter ..	Jupiter	0.5 N.
19d 01h	Venus ..	Venus	5 N.
20d 20h	Mercury ..	Mercury	7 N.
31d 07h	Saturn ..	Saturn	4 S.

In addition to these conjunctions with the moon, Mercury is in conjunction with Mars on March 16d 17h, Mercury being 3.7° N.

The Planets.—Mercury is in inferior conjunction with the sun on March 8 and is not favourably placed for observation in the early part of the month. On March 15 the planet rises at 5h 42m (about 35 minutes before sunrise), and on March 31 at 4h 54m (three-quarters of an hour before sunrise), and can be seen in the eastern sky. The stellar magnitude of the planet varies between 1.4 and 0.9 during the month. Venus is still a morning star, rising at 5h 02m, 4h 57m, and 4h 40m at the beginning, middle and end of the month respectively. The stellar magnitude of Venus varies from 3.8 to 3.6 during March. Mars is too close to the sun for favourable observation.

Jupiter can be seen in the morning hours a little west of the star γ Scorpii, rising at 0h 48m and 22h 49m at the beginning and end of the month respectively. The stellar magnitude of the planet is about 1.8 during March and its distance from the earth varies from 475 to 435 million miles. On March 14 Jupiter is stationary and its movement after this with reference to the stars is retrograde, that is, it appears to move from east to west. This is due to the motions of Jupiter and the earth round the sun, these motions, in the positions occupied by the two planets, producing the impression to an observer on the earth that Jupiter has changed his direction of motion with reference to the stars. Saturn can be seen in the morning hours, setting at 5h 37m, 4h 39m and 3h 35m at the beginning, middle and end of the month respectively.

A Film on Productivity

In these days of rationing, queueing, utility standards and high prices, there are surely few with whom the standard of living is not a major preoccupation. Every day the Press carries some item of political or industrial news concerning the need for increased production and, by implication, its main purpose—that of increasing the nation's standard of living. The economics connecting these two things—national productivity and the needs and comforts of the individual—are perhaps only vaguely appreciated by the man in the street.

It seems strange, then, that greater use has not been made of the film medium in bringing to the public a more scientific understanding of this vitally important subject; for the scientific film, which is coming increasingly to the forefront as an instrument of public education in such fields as medicine, the natural sciences and agriculture, seems to have been unusually reticent on what is rapidly becoming one of the basic human sciences—economics.

One such film has in fact recently been made; it is the first of a series called "Focus on the Future" intended to deal with future trends in industry. Entitled *Can We Be Rich?* the film runs for approximately thirty-five minutes; it has been made with the technical collaboration of Mr. Geoffrey Crowther, editor of *The Economist*, who appears in person on the screen during a great part of the film and holds a dialogue with the invisible commentator.

Regarded both as filmcraft and as a piece of exposition on economics, this film leaves much to be desired. True, unbiased scientific approach to some economic problems is difficult owing to conflicting political considerations; but something more solid and satisfying, less superficial, could surely have been made.

The first half of the film certainly presents what appears to be a logical sequence of ideas in elementary economics, an argument which develops in orderly fashion. The solution to nearly all the problems of the post-war period, we are told, depends upon that of a more fundamental one—how to maintain or even raise the country's standard of living. This is defined in simple everyday terms—food, homes, clothes, health services, recreation, holidays; and Mr. Crowther says it can and must be raised. By considering a completely isolated community—Robinson Crusoe on his island—which can only consume the identical things it produces, and leading from this to the fact that Britain, too, can within narrow limits consume only the equivalent of what she produces, the connexion between total national production and standard of living is established: the more a community can produce, the higher can its standard of living be. The film then shows the basic part played by mechanisation in increasing productivity: "In the countries of Europe as well as America, each pair of hands has a host of machines, instruments and devices to help them . . . the complex and advanced production methods made possible by Science." The

concept of P.M.H. (Production per Man Hour) is introduced and we are told that the American figure is usually higher than the British owing to the greater amount of machinery available to each worker.

It is not so much in the film's arguments as the way in which they are put over that imperfections are evident: many of the scenes have been duplicated from other films or obtained from film library material, with consequent loss in photographic quality; in general the animated diagrams show lack of imagination and are poor in execution; the musical accompaniment tends to be over-dominating. But more important than these defects is the fact that by its attempt to put a complex subject in a popular form the film has achieved in places a certain slick facetiousness which is not only irritating but pointless. For instance, in order to clarify the explanation of national production and output Mr. Crowther likens these to the making and baking of a cake, the ingredients of which are labour, materials and the machine. This analogy, simple and straightforward enough in itself, is in no way helped by the illustrative sequence introducing it. A character dressed as John Bull, with all the airs and graces of a showman, occupies a modern kitchen; the paraphernalia of film trickwork are used to change his clothes into those of a chef and to 'jump' into his outstretched hands a cake-tin, a mixing-bowl and packets of ingredients. Such filmic conjuring does not advance the discussion; it does not, as it is probably intended to do, make the exposition more 'acceptable', but serves merely to cheapen the impression made by the film as a whole on any audience intelligent enough or interested enough to follow the general argument.

This argument is on a national rather than an international basis: the 'we' in the film's title represents Britons rather than the man-in-the-street all over the world. It is a theme, moreover, which sets a strictly materialistic meaning on the word 'wealth': happiness would appear to consist mainly in television sets and vacuum cleaners (perhaps for many of us it does, these days). Oddly enough though, reference is omitted to a hypothetical age of atomic power when we will all be able to live like princes in return for the labour expended in pushing a button once daily.

The film ends with a controversy between a trades unionist and an employer, both exaggerated characters, over how production should be increased; the sequence in which Mr. Crowther intervenes to keep the peace between them contrives to leave the impression that it is all just too easy, and if only management and labour will play ball together and we somehow find lots of nice new shiny machines, our productivity will leap upwards.

But whatever its shortcomings, this is a film which should provoke healthy discussion amongst most audiences on the young science of economics.

DENIS SEGALLER.

(This review is contributed by arrangement with the Scientific Film Association.)

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The Bookshelf

Social Biology. By Alan Dale. (Heinemann, London, 1946; pp. 396; 15s.).

This book is based upon a Sixth Form course for pupils not necessarily 'scientists'. It is an attempt to assist the general understanding and valuation of biology in so far as it affects human well-being. Despite the title, it is more a general account of human biology than a consideration of the special biology of human social relationships.

Readers of *DISCOVERY* will find this book of great interest and of considerable value in providing a basis for further thought and discussion. But its usefulness in adult education would have been increased had more space been allowed for presenting the facts of human biology, including those measured by vital statistics, and for considering the methods (1) by which those facts are assembled and (2) by which the conclusions at present based upon them are reached. Only in this way is it possible to evoke from the student a scientific outlook, as distinct from the reactions of wonder or dutiful respect.

The author, presumably on account of the particular origin of the book, appears to assume that the reader is familiar with general science. In consequence many adults will find the standard of treatment too exacting. This is to be regretted, since important subjects such as man's food, his health, his hereditary endowments, his problems of sex and marriage, and those special human characteristics that have led, so far, to the advancement and survival of man are all very well discussed. The price of the book will also react unfavourably against wide distribution. But for adult students of Tutorial Class standard the book can be strongly recommended on account of its lucidity, its wealth of illustrations and the general balance preserved by its author when discussing controversial questions.

M. H. CLIFFORD.

Elementary Theory of Gas Turbines and Jet propulsion. By J. G. Keenan. (Oxford University Press, London, 1946; pp. 261; 15s.).

The writer of a book on such a recent development as the Gas Turbine is faced with two alternatives—he can either assume that his reader does not know even the first principles of any form of heat prime-mover, or else it can be taken that, understanding the workings of an internal combustion engine and steam turbine, he wants to understand the latest evolution of these engines. This book is written to fulfil the former condition, and as such there is no doubt that it is a clear and well-presented summary of the fundamental aspects of the subject.

Assuming only an elementary knowledge of mathematics and mechanics, the author leads from a short historical account and an elementary treatment of the physics of gases to a description of the two types of compressor used. Following the path of the air, combustion chambers and nozzles are dealt with next, after

which he comes to the turbines themselves. Finally, a brief discussion of jet propulsion and other uses of the gas turbine is given.

The reviewer feels, however, that the author has been too concerned with the first category of reader, and has consequently made the book of little value to the initiated, to whom well over half of the subject matter will be familiar from general physics and steam turbines. Due allowance must be made, of course, for the fact that at the time the book was written much information about actual turbines was restricted, but now that it has been released it makes some of the text seem rather over-simplified. The omission of any reference to the problems set up by the phenomena of compressibility—other than an erroneous statement that a 'shock' wave is really a sound wave—is a serious one, even in an elementary treatment.

It is a pleasure to see reached once again, after grim austerity products, the high standard of book production which one always expected from the Oxford University Press. Is it too much to hope that this book may be the precursor of an ever-increasing and improving stream of books from the publishers in general?

J. BLACK.

Compass of the World. Edited by H. W. Weigert and V. Stefansson. (Harrap, London, 1946; pp. 466, 39 maps and figures; 15s.).

This is a symposium on political geography made up of 28 studies grouped under six headings. The first group deals with the ideological aspects of geography in world politics; the second with the fundamentals of the new geography of skyways; the third is devoted to the concept of the Heartland originated by Mackinder. The fourth is concerned with the northward course (i.e. the North as a pivotal zone in a world whose land and sea lanes are supplemented by air lanes), the fifth discusses problems in the political geography of Asia and the last group takes up the important question of the shifting balance of manpower. More than half of the material consists of reprinted material which has been revised and brought up to date by the authors. The work is mainly American, though there are two outstanding studies by Mackinder and James Fairgrieve.

As in all symposiums of this kind, overlapping and repetition could not be avoided. But it sometimes helps to stress a point, and on the whole, the work contains a great amount of information not currently available on this side of the Atlantic. Unfortunately all the material was written before the appearance of the rocket and the atomic bomb, and therefore, relates to the pre-atomic age. The reader must judge for himself how much the advent of atomic air power has changed geopolitics conceived as recently as the latter half of the war. It is unfortunate that the editors did not find it possible to include at least one study giving a rough idea of the geopolitical revolution brought

about by the stupendous discoveries of the last three years. Yet there is ample material in this book to provide a useful basis for reflection on geographical politics and strategy of 1947.

E. M. FRIEDWALD.

Britain's Structure and Scenery. By Professor L. Dudley Stamp. (Collins, London, 1946; pp. 255, 16s.).

This, the fourth and latest addition to the 'New Naturalist' books, fits well into the general scheme of this series. It may, in the Editors' prefatory words, be regarded as "the background volume of the whole series" for it provides "a general view of the stage and setting for Britain's Natural History".

The first essential in a book of so wide a scope is to give an adequate introduction to the basic principles of earth science in non-technical language. This is necessary in order to appreciate the way in which the several tools for wearing down the land—weathering, rain, rivers, sea, ice—have selectively acted on the rocks according to their varied character and disposition, and so given individuality to the scenery. To this Professor Stamp allots more than one-third of his space. He accomplishes it with a sure grasp of essentials and a facile and, one suspects, rapidly moving pen.

The bulk of the middle section of the book is a substantial chapter called 'Geographical Evolution' which is a readable account of the building-up of the composite mass of rocks which make up the foundation framework of Britain. That title belongs more particularly to latter part of the chapter and to the two succeeding ones ('The Pliocene Period' and 'The Great Ice Age') for it is to this part of Britain's history that the geographical evolution of its landscape belongs. Technical expressions may cause some difficulty. Some are probably unavoidable; but others could have been eliminated without serious loss. This obstacle is likely to be smaller for the younger generation of readers than for the older in view of the increasing recognition of the necessity for a knowledge of the fundamentals of earth evolution as a scientific foundation in all geography teaching.

The third section is a descriptive account of the scenic features and their origin for the whole of Britain in nine regional studies. This is really the heart of the story. It is attractively presented, but there are great differences in the adequacy of the treatment. The country south-east of the Severn-Wash line receives 44 pages as against 18 for the whole of the rest of England and Wales, in spite of the greater variety of the latter. Consequently some aspects of regional importance are barely mentioned.

There are a regrettably large number of minor misstatements and inaccuracies which, while they do not seriously impair the general story, will it is hoped be eliminated in the reprinting that may be confidently anticipated.

The numerous illustrations are admirable. The colour photographs which are a feature of this series will, in spite of their overtones of blue, enhance the popularity of the book and do much to stimulate many to a fuller appreciation of the country's scenic heritage.

S. E. HOLLINGWORTH.

A History of Western Philosophy and its Connection with Political and Social Circumstances from the Earliest Times to the Present Day. By Bertrand Russell. (Allen & Unwin, London, 1946 pp. 916; 21s.)

This large book is, in the words of the author, an attempt "to exhibit philosophy as an integral part of social and political life: not as the isolated speculations of remarkable individuals, but as both an effect and a cause of the various communities in which different systems flourished." It combines remarkable scholarship with a simple and easily readable style of writing, and is throughout liberally laden with typical Russellian wit and humour. Thus Pythagoras is described as "a combination of Einstein and Mrs. Eddy"; Aristotle as "Plato diluted by common sense"; while the imaginary conversation between Nietzsche and Buddha is a masterpiece of wit.

It is easy, as the author himself admits in the preface, to pick holes in a book which reviews and discusses such a wide range of complex thought as this one does. But it is little help to the reader to be told that he treats Locke 'well', Berkeley 'very badly', and Hume 'moderately' (Ritchie), or that he is unfair in what he says of Plato and is in fact still greatly influenced by him—this latter of course by a Platonist (Joad)—unless these statements can be supported by a large array of factual evidence, which is impossible in a review. Russell is of course biased in his assessment of the philosophers whom he is discussing. He is on his own admission a 'member' of a philosophical school—that of Logical Analysis—whose outlook differs radically from that of many of the philosophers, both ancient and modern, whose work he discusses.

Russell's outlook is dominated by the use of a powerful form of logic which finds its roots in the earlier systems of Locke and Hume, but differs from them in incorporating mathematics. This has led to the development of a very powerful new technique of inquiry of which he is an outstanding exponent. This technique of analytical empiricism made possible new attacks on many of the older philosophical problems such as, for example, "What is number? What are space and time? What is mind, and what is matter?"

Russell claims that here is a method by which "we can make successive approximations to the truth, in which each stage results from an improvement, not a rejection of what has gone before". It does not give rise to a system-philosophy, problems being tackled one at a time, but it does as a result of its stable technique lead inevitably to definite answers to certain problems, and is an approach

which is compatible only with a belief in absolute truths.

Russell does not entirely reject metaphysics (see *An Enquiry into Meaning and Truth*, American Edn., p. 437), although often he appears to wish to do so, but rejects the systems of metaphysics of the older philosophers in favour of his own un-systematic 'Atomism'. The effect of this outlook is seen throughout the *History of Western Philosophy* which may well be termed a monument of mental anarchism. Politics, metaphysics, logic are all treated alike. Plato, Aristotle, the medieval theologian-philosophers, Marx and Dewey (stigmatised as a 'power' philosopher) all receive equal obloquy, for the same reason—Russell's atomistic approach—but on account of different aspects of their work. In the words of Louis MacNiece:

"... Logic and Lust together
Come dimly tumbling down
And neither God nor No God
Is either up or down."

On the other hand some of the earlier Greek philosophers (e.g. Democritus) and the later empiricists (e.g. Locke, Berkeley and Hume) are treated with kindness and evident liking.

The analysis of the relationships and inter-actions between philosophers and their times is often masterly, even when Russell deals with those whom he dislikes; for example, the medieval theologians and the later German romantics.

This book is the product of a great logician, a great anarchist and a formidable wit—one of the most brilliant of living minds. It is a book which all can read, and everyone who thinks should read—professional philosophers included.

DEREK WRAGGE MORLEY.

An Introduction to Chromatography. By T. I. Williams. (Blackie, London, 1946; pp. 100, 8 plates; 10s.)

ACCOUNTS of chromatographic adsorption which have hitherto appeared have fallen into two groups. They have either been limited to rather brief descriptions of methods and some spectacular applications, or they have attempted to deal exhaustively with the many achievements of chromatography and the means by which they were attained. There was always more justification for the former type of review than for the latter, for chromatography is merely an almost empirical separatory method for handling mixtures (mainly organic); the selection of the apparatus, which is almost invariably simple, choice of solvents, and other details become part of ordinary laboratory practice, comparable with and hardly more complex than the organic chemist's attention to details of, say, crystallisation. Collections of detailed descriptions of many chromatographic separations seem unfruitful because the detail is rarely applicable to other separations, each new example calling for individual judgment.

The present book seeks a middle way in describing quite briefly the more common chromatographic techniques with a few

examples, freely adding small practical hints to avoid some of those mistakes which spring from unfamiliarity, and including some indication of the impact of theory on the practice of chromatography.

There is no doubt that a chemist knowing nothing of chromatography and relying on the present work would find himself able to bring many of the resources of the method to bear on his own problems without more personal instruction or lengthy experience. He would find timely information on the standardisation of adsorbents, their choice and use, various forms of glassware, procedures, partition chromatograms and other matters. It may be added that he would also find much information which is of only historical interest, apparatus that he would hardly attempt to reproduce (such as the tap-less dropping funnel on p. 23), a few illustrations which though well-produced portray no exceptional achievements and convey no special lessons, and examples of chromatograms which, as his horizons widen, will seem scarcely representative. All the detailed examples describe the concentration of small quantities of biologically interesting materials from large bulks of starting material. He cannot fail to notice many advances in biochemistry which would almost certainly not have been made as promptly, if at all, without chromatographic aid, and elsewhere in the book he is told of rather academic experiments in inorganic analysis and, in passing, of some of the byways of chromatography in examining wines, foods, and drugs. It may escape him, however, that chromatography can assist almost any preparative organic chemist as well as many others. He will surely perceive many of its possibilities as a refined and delicate technique, and may even be overawed by the detail as it appears in general terms; but he may not at once appreciate its assistance which can spring as readily to mind and hand as that afforded, for example, by his filters and test-tubes in crystallisation. This small book will thus be most useful as a clearly written laboratory handbook which, once the chemist has been persuaded to try chromatography, can save him much time and patience.

A. H. COOK.

On Scottish Hills. By B. H. Humble. (Chapman & Hall, London, 1946; pp. 128, 75 photographs, 5 maps and diagrams; 18s.)

EVEN without the text Mr. Humble's photographs will awaken memories and desires in anyone familiar with Scottish mountains. He has shown the more famous of these mountains in many moods, through the eyes and by the camera of one who knows them intimately. The text will please those who know the districts but may confuse the stranger. There is no doubt where the author's heart lies and the book is a welcome and worthwhile addition to Scottish mountain literature. It should encourage all open-air enthusiasts to visit or revisit these more unfrequented places.

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